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POLICY OPTIONS FOR GREENHOUSE GAS MITIGATION IN CALIFORNIA: PRELIMINARY RESULTS FROM A NEW SOCIAL ACCOUNTING MATRIX AND COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODEL

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The present report was authored by researchers at the University of California, in consultation with Energy Commission staff and other professional colleagues. Dr. Peter Berck supervised the development and documentation of the 2003 California Social Accounting Matrix, and Dr. David Roland-Holst supervised development and documentation of the CGE model and the simulation results reported here. Special thanks to Max Aufhammer, Guido Franco, Michael Hanemann, and Alan Sanstad for valuable input. All remaining errors are those of the authors, as are any opinions expressed in this document.

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California's electricity and natural gas ratepayers. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's Public Interest Energy Research (PIER) Program established the **California Climate Change Center** to document climate change research relevant to the states. This Center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts and the efforts designed to reduce emissions.

The **California Climate Change Center Report Series** details ongoing Center-sponsored research. As interim project results, the information contained in these reports may change; authors should be contacted for the most recent project results. By providing ready access to this timely research, the Center seeks to inform the public and expand dissemination of climate change information; thereby leveraging collaborative efforts and increasing the benefits of this research to California's citizens, environment, and economy.

Policy Options for Greenhouse Gas Mitigation in California: Preliminary Results from a New Social Accounting Matrix and Computable General Equilibrium (CGE) Mode is the final report for the Preliminary Economic Analyses of Climate Change Impacts and Adaption, and GHG Mitigation project (contract 500-02-004, and work authorization MR-006) conducted by the University of California, Berkeley, Department of Agricultural and Resource Economics..

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For more information on the PIER Program, please visit the Energy Commission's website www.energy.ca.gov/pier/ or contact the Energy Commission at (916) 654-5164.

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Abstract

This report describes the construction of a new Social Accounting Matrix (SAM) for California, estimated for 2003, and uses it with a statewide economic model to examine policy options for greenhouse gas (GHG) emission reductions in the state. The 2003 California SAM sets new standards for detail and accuracy, and the computable general equilibrium (CGE) model provides new insight into GHG abatement strategy and its effects. While the results presented here are preliminary, they indicate the state has ample scope for GHG mitigation. At the same time, it is clear policies must be carefully designed to recognize incentives and adjustment needs across affected sectors and other stakeholder groups. Among other considerations, firms will contribute most to the state economy if they make investments that promote both energy efficiency and innovation. Even relatively modest rates of productivity growth would enable California to reconcile environmental and growth objectives, substantially reducing GHGs while stimulating the economy.

Keywords: Social Accounting Matrix, SAM, computable general equilibrium model, CGE, greenhouse gas, GHG, economic model, GHG mitigation

Executive Summary

To support a new generation of policies for greenhouse gas (GHG) mitigation in California, this project has developed a comprehensive new database and forecasting model (the Computable General Equilibrium economic model) with funding from the California Energy Commission's Public Interest Energy Research (PIER) Program. This report briefly documents this tool and presents examples of how it can be applied in a variety of GHG and energy-related policy areas—including the development of preliminary estimates compared across several individual and combined scenarios.

This preliminary report illustrates the new research capacity, with examples from three GHG policy areas that represent the main types of policy instrument:

1. **Cap and Trade Systems.** These policies target a quantity restriction on emissions, and the target can be achieved by quota systems that are source-specific or tradable, or by tax/subsidy instruments. Three examples illustrate this approach: (1) a tradable quota (this scenario is labeled CO2CAP); (2) an equivalent tax (CO2Tax); and (3) efficiency requirements needed to achieve the same mitigation without intervention (CAPInno).
2. **Industry policies.** These are mitigation policies targeted at production activities in agriculture, manufacturing, and services. Included is an example of the Renewable Portfolio Standard (RPS), which mandates fuel substitution in the electricity sector.
 - a. **Household policies.** These are policies targeted at individual consumption. The main categories are: residential energy use and demand for personal transportation services. Examples of the household policies discussed are: (1) the Pavley Bill (AB 1493, Pavley, Chapter 200, and Statutes of 2002), which would mandate minimum GHG standards for certain vehicles; (2) EELR (Energy Efficiency in the Long Run), which corresponds to state public promotion cost estimates and the benefits of

promoting private energy efficiency; and (3) PV (Photovoltaic), a scenario for adoption of photovoltaic cells in construction.

In the report's forecasts, each scenario is evaluated against a "business as usual" or baseline reference scenario over the period 2004–2020. This comparison enables analysts to evaluate GHG policies individually and in combination, and is subject to changing economic (and other) assumptions, which permits researchers to evaluate different baseline assumptions.

Although the Computable General Equilibrium (CGE) model is still under development and has only been applied to a small set of the policies it was being designed to study, the scenarios mentioned above already offer useful insights. Figure ES.1 displays total statewide GHG emissions under seven scenarios.

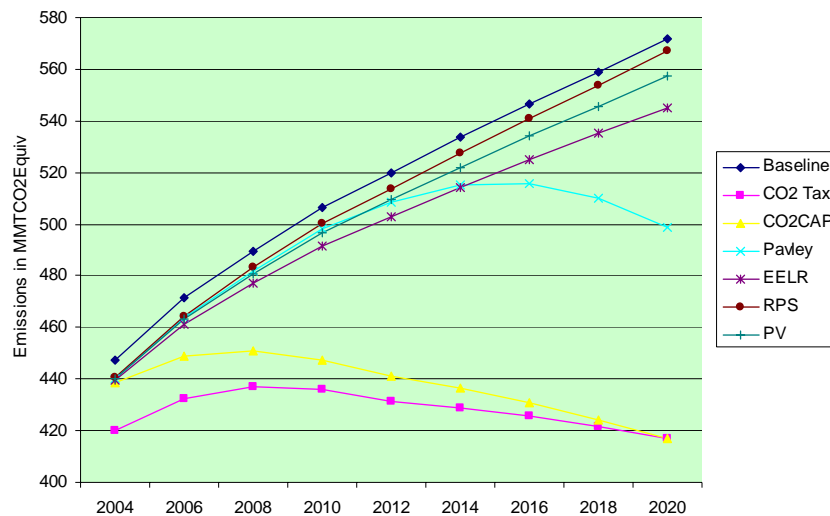


Figure ES.1: Statewide GHG Emissions

The salient characteristics are as follows:

1. Cap-and-trade mechanisms have the potential for substantial and direct GHG mitigation.
2. A vehicle-oriented measure like the Pavley Bill could confer substantial GHG mitigation.

3. Long-term energy efficiency gains in residential energy use are very predictable at the macro level, but their full implications to the different sectors are not straightforward.
4. Effects of the RPS on GHG emissions appear relatively modest, mainly because the sector has relatively small intermediate hydrocarbon use within California.

These general conclusions arise from many more detailed structural adjustments simulated by the CGE model, the analysis of which can be essential to effective policy implementation. To develop effective programs, policy makers need to understand how different stakeholder groups would be affected.

Figure ES.2 shows the percent changes in GHG emissions from production sources, and Figure ES.3 shows the percent changes from households, based on different policies.

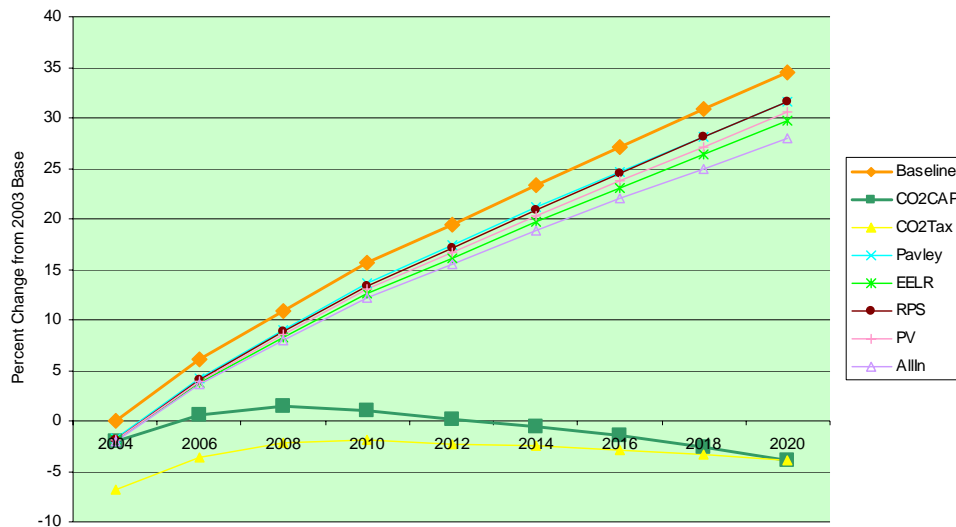


Figure ES.2: Percent Changes in GHG Emissions from Production

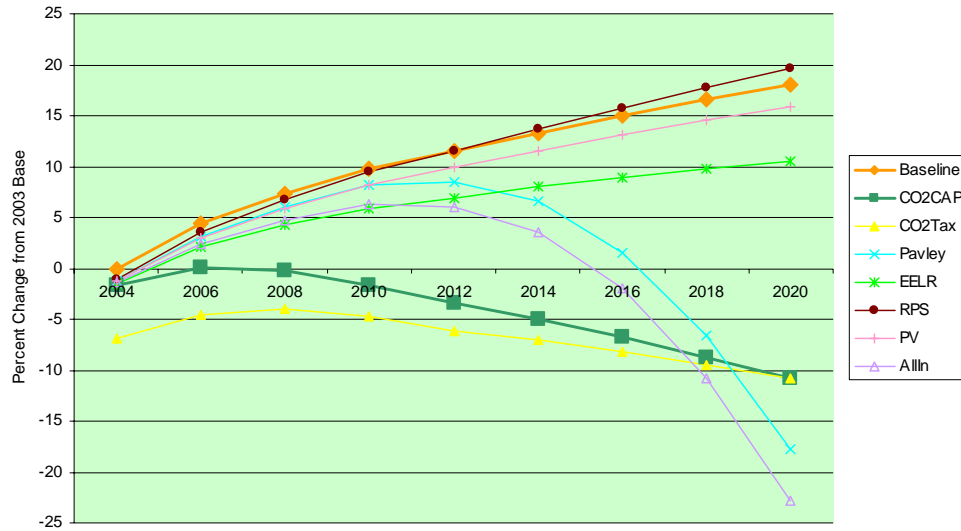


Figure ES.3: Percent Changes in GHG Emissions from Household Consumption

Most of the differences here are intuitive; however a few comments are in order:

1. In all cases, households make greater quantity adjustments because they are more price-responsive. This finding reflects an important combination of assumptions about behavior and price transmission that need closer attention.
2. The CO2Cap affects total pollution, but the tax is only on industrial sources. Because of price effects, however, households also reduce energy use and pollution; in fact, households experience greater mitigation in percentage terms. Thus, both the directly and indirectly affected groups can contribute to energy savings.
3. Households are responsible for the lion's share of mitigation under Pavley, but their reduced energy demand leads to lower energy requirements (and pollution) by industry. This is a good example of a "greening" compositional effect arising from shifts in sectoral demand patterns.

4. EELR is an across-the-board, per capita household efficiency gain, so the aggregate results are very predictable from calibrated direct effects. They are relatively small (1%/year), because the experiment is small.
5. Households use more energy under both the RPS and PV scenarios because of positive income effects from conservation and lower energy prices. In the case of PV, this indirect price effect is enough to reverse the intended aggregate outcome by 2020.

Policy makers relying on intuition alone are unlikely to foresee significant implications of their actions; therefore, policy analyses benefit from combining economywide modeling, which captures linkage and indirect effects, with more traditional bottom-up and sector-specific policy analysis.

1.0 A SAM for California

This document describes the construction of a Social Accounting Matrix (SAM) for California. The SAM is a record of the transactions between institutions, such as consumers, firms, and government, for the calendar year 2003. It is based upon multiple sources, including input-output tables, California tax and spending records, and California employment data. This SAM includes energy and uses the California Energy Balance Database (CALEB) for 2000, the most recent data available. The document also describes the construction of ancillary tables, including the capital coefficients matrix, which records the uses of investment, and several miscellaneous tables which record tax system details, among other things.

Although the numbers in this SAM are wholly created from recent data, the SAM inherits its structure from the SAMs used for the Dynamic Revenue Analysis Model (DRAM).¹ The following description borrows from the previous documentation, most heavily so in those areas where the new SAM inherits its structure from the previous SAM.

1.1. Data Organization: Social Accounting Matrix

For the purposes of statistical description, the California economy is divided into 158 distinct sectors. Each sector is an aggregate. For industrial sectors, the aggregation is over closely related industries. So an industrial sector is a list of the aggregate purchases and sales of these related industries. Similarly, a consumer sector shows the income and expenditures of a group of consumers and a government sector shows the income and expenditures of a type of government.

A SAM is a square matrix consisting of a row and column for each sector of the economy. Each entry in the matrix identifies an exchange of goods and services purchased by one sector from another sector or itself. The entries along a row in the SAM show each payment received by that particular sector. Summing the data across the row gives the total of payments made to that sector. The entries down a column in

¹ Dynamic Revenue Analysis for California. Department of Finance, State of California, Summer 1996. http://134.186.99.249/html/fs_data/dyna-rev/dynrev.htm.

the SAM show the expenditures made by a particular sector. Summing the data down a column gives the total expenditures by sector.

The California economy has been represented in a SAM composed of 158 distinct sectors: 92 industrial sectors, 2 factor sectors (labor and capital), 8 household sectors, 9 composite goods sectors, 1 investment sector, 45 government sectors, and 1 sector which represents the rest of the world. The design of the sectoring is an important element in the development of any Computable General Equilibrium (CGE), Social-Accounting, or Input-Output (IO) model, because it determines the flows that the model will be able to trace explicitly. If the sectoring is done well, the major flows in the economy, both positive and negative, will be evident. If the sectoring is done poorly, the impact of policy will be blurred, with negative and positive flows occurring within a single sector.

The following sections present the criteria for the sectoring of the SAM and describe each sector. The data sources for each sector are also discussed. The first section examines industrial sectoring. The second section discusses the model's two factor sectors. The third section describes the household sectoring. And the fourth section describes the government sectoring.

1.2. The Industrial Sectors

In this SAM, the research team chose to follow the North American Industry Classification System (NAICS) method of describing industrial sectors. The NAICS system is a six-digit classification. The codes are arranged so that major classifications share the same first digit—for instance, agriculture, hunting, and forestry all have 1 as the first digit. Crop production sectors all have the same first three digits (111), while animal products are 112. This study's industrial sectoring basically follows the first three digits of the NAICS codes, with some exceptions that are discussed below. By following the NAICS codes, this study was able to match different types of data, like employment data and input output data, with a fair degree of accuracy. In the future, when the NAICS system is completely adopted, without variation, by the major government statistical entities, perfect matching will be possible.

By using the three-digit NAICS codes as the basis for sectoring this study achieved a very fine (for a SAM) differentiation among sectors.

The table in Appendix A displays the names of the sectors, their descriptions, and their concordance with the NAICS system.

1.2.1. Major California Industries

The first criterion considered when establishing adequacy of the industrial sectoring is the importance of the industry in terms of its revenue and employment. Tables 1.1 and 1.2 display these figures. The largest net output sectors in the state are real estate, retail, computer related manufacturing, business services, banking, transportation, machinery, electronic parts manufacturing, agricultural manufacturing and agriculture.

**Table 1.1: Ten Largest Industries by Value of Total Payment
From Other Sectors (in billion \$)**

Sector	Output (in billion \$)	Ratio to All Industry Output (%)
RETAIL	125.99	6.68
FIREAL	117.921	6.25
FIBNKS	74.514	3.95
CMPMFG	61.346	3.25
AGRIC	55.693	2.95
INFOPC	52.288	2.77
MEDAMB	51.275	2.72
CMPRTS	51.145	2.71
WHLTUR	51.043	2.70
CONOTH	48.734	2.58
Total output in all industry	1887.199	

The ranking of major industries according to the number of employees presented in Table 1.2 reproduces results similar to those in Table 1.1; service and trade industries are the dominant employment sectors for the state.

Table 1.2: Wage and Salary Workers by Major Industry, 2003

Sector name	Employment	Percent of total employment (%)
RETAIL	1,584,938	12.74
PERSRV	619,458	4.98
CONOTH	519,176	4.17
MEDAMB	498,262	4.00
ACCRST	458,189	3.68
ACCFST	435,385	3.50
ADMTMP	428,136	3.44
TRANSP	419,580	3.37
BUSSRV	406,096	3.26
AGRIC	374,047	3.01
Total industry employment	12,441,952	

Source: Averaging employment levels in Employment Development Department (EDD) data over Q2 2002 through Q1 2003.

The retail sector has the largest employment in the state, with 13% of the total employees.

In terms of sectoring, this scheme has isolated most of the potential targets for tax policy—particularly in the manufacturing sectors. Table 1.3 shows the major taxpayers in 1992.

**Table 1.3: Firms Reporting Net Income Subject to State Taxation of
\$1 Billion or More, 1992 (in thousand \$)**

Industry	Net income subject to state taxation
Investment and Insurance Companies	5,320,185
Wholesale Trade	4,126,940
Banks and Savings and Loans	3,388,928
Retail Trade	3,341,524
Electric Machinery and Equipment	2,636,639
Communications	2,537,911
Electric, Gas, and Utilities	2,406,728
Business Services	2,091,496
Petroleum, Coal, and Rubber Products	1,761,465
Beverages	1,608,991
Real Estate	1,538,680
Chemicals and Allied Products	1,512,653
Construction	1,088,195

Source: Information reported in the California Statistical Abstract, DOF 1994.

Note: The treatment of taxation sectors remains the same in this SAM as in the 1998 SAM. All of these sectors are well isolated in this study's sectoring scheme.

The third criterion considered when establishing the industrial sectoring is the distributive impact of government taxation and spending. In order to trace effectively the impacts of government spending and taxation on the distribution and incidence of production, income, spending, and savings in the economy, it is important to establish an industrial sectoring that can be used to map the effects of government policy. The sectoring in SAM distinguishes those industries that clearly stand to benefit from increased government spending from those industries that may incur negative repercussions from such spending.

As a first cut at differentiating the impacts of government policy, it is important to distinguish major taxpayers by size and by type of tax, as was done in the previous

section. Not only do the major taxpayers represent the primary source of funding for government spending, they also represent important variables in any industrial-development strategy. Targeted tax cuts or even general tax cuts to industry are primary tools in industrial-development incentive policy. The industrial sectoring must explicitly include the major taxpayers in order to trace the impact of such policies.

The industrial beneficiaries of government spending on infrastructure or education are difficult to isolate. Both theory and empirical observation suggest that the benefits of infrastructure and education are diffused throughout the economy. The direct beneficiaries of industrial-development spending are likely to be more narrowly delineated. A primary focus of many industrial-development strategies has been creating employment in wage-premium, high-export industries. Wage-premium jobs have a high salary-to-education ratio, and the earning effects of local employment are greater for new jobs in wage-premium industries. More jobs at higher wages provide the biggest “payoff” for employment-creation projects. Export industries are targeted because out-of-state earnings can have large, economywide impacts.

California’s largest wage-premium export industries (in 1998) were Aerospace, Motion Pictures, Engineering and Management Consulting, and Computer Software and Systems Development. Even if these industries are not specifically targeted by development incentives, they are important industries to track with the model. The economywide impact resulting from changes in these industries should be large, because they are large employers paying high salaries, making large export earnings. Again, these sectors are well isolated in this study’s sectoring scheme.

The sectoring scheme mostly differs from a straight three-digit NAICS setup by the breakout of energy- or pollution-important sectors (for instance, cement, natural gas distribution and power generation). These sectors were selected for special treatment by ranking the 4 and lower digit NAICS sectors, so far as data would allow, by energy usage and preserving those with high energy usage as sectors by themselves. Table 1.4 shows the energy purchases by the major energy-producing sectors in the study’s final sectoring.

Table 1.4: Industry Total Purchases of Goods from Energy Industries (all billion\$)

OILREF	21.46928	PLASTC	0.340307	TEXLTH	0.173429	PROOTH	0.08295
DSTGAS	6.111024	ACCHOT	0.331747	FDPROC	0.172258	PROCOM	0.081157
DISTEL	4.290048	CHMDRG	0.324989	FINOTH	0.155621	CONCRT	0.063585
FIREAL	3.413969	PRINT	0.314367	ADMBLD	0.144514	PROLEG	0.06302
TRANSP	2.517194	INFOPC	0.314333	WOOD	0.1398	CMPCMM	0.055395
AGRIC	2.334113	WHLNON	0.310282	CONUTL	0.130648	CMPMED	0.05102
OILGAS	2.193922	PRIMTL	0.277611	SCAOTH	0.12783	DSTOTH	0.050288
CONOTH	1.125058	MEDAMB	0.263604	EDUC	0.123511	ACCSPC	0.048594
OTHPRI	0.744965	FINSEC	0.245905	APPREL	0.122085	VEHPRT	0.047999
CHMBAS	0.627995	CONNON	0.223896	ELCTRC	0.120694	INFCOM	0.042115
BUSSRV	0.596703	FIBNKS	0.223319	INDGAS	0.119477	PROADV	0.038759
PERSRV	0.572432	MACHIN	0.222316	FDMFG	0.119465	PROCNS	0.036452
RETAIL	0.56207	CMPMFG	0.217954	CEMENT	0.112848	ADMSEC	0.036121
WHLTUR	0.540194	INFOTL	0.215443	PAPER	0.106925	PROACC	0.031906
CMPRTS	0.518327	BEVTOB	0.209393	WHLGN	0.106565	AUTOMF	0.024037
FDOTH	0.472232	CHMSPS	0.208917	PROARC	0.101806	PRODES	0.022482
ACCRST	0.469289	RECAMS	0.203625	GLASS	0.099425	ACCBRS	0.020381
CONSTR	0.456687	VEHAER	0.192586	MSCMFG	0.097282	VEHOTH	0.02032
ADMOTH	0.424884	CMPINS	0.19117	LABDNT	0.096067	VEHBDY	0.015226
CONRES	0.379514	MEDSA	0.18653	RECENT	0.095344	VEHSHP	0.012382
ACCFST	0.364136	PRORES	0.185788	INFOTH	0.092498	VEHMFG	0.007515
MTLFAB	0.354626	MEDNRS	0.179013	PLPMLL	0.091634	FINSUR	0.007218
MEDHSP	0.347479	CHMOTH	0.174594	FURN	0.090092	ADMTMP	0.005305

To evaluate pollution control, including GHG control proposals, the automotive sector has been preserved in less than three-digit aggregation. Automobile and light truck

manufacturing is kept distinct from heavy trucks; and body manufacturing and parts manufacturing are distinct industries.

1.2.2. Producing the Energy Consistent SAM for Industries

The fundamental method for producing the SAM rows and columns for the industries was to use the Bureau of Economic Analysis (BEA) data for 1997 to create an Input-Output table for the United States. The columns of the U.S. table for each industry were then scaled by the ratio of wages paid in the industry in California in calendar year 2003 to those paid in the United States in 1997. This scaling produced estimates of the expenditures and revenues of California industry for 2003.

The industry flows estimated from the BEA data are not entirely consistent with the energy flows in CALEB, which are based on energy data. The reasons for the differences include: (1) the fundamentally different sources for the data: data on firms versus data on energy flows, and (2) the construction of California from national data described above. In order to make the SAM consistent with CALEB, the CALEB data for energy use were assigned to the SAM sectors, to derive the use of each energy type by each sector in energy units (trillion Btu). Then, these data were combined with 2003 price information to correct the major SAM energy transactions for the actual Btus that changed hands at the actual prices. For example, the purchase of wholesale natural gas by the gas distribution sector (i.e., the payments made by DSTGAS to OILGAS) reflect actual Btus at the average 2003 utility gas procurement price. Further, smaller purchases by end-use sectors were also adjusted for the changes in energy prices from 1997 to 2003, which were generally larger than wage inflation.

1.3. The Factor Sectors

A *factor of production* is a stock that generates a flow of services used in the production of goods and services. In a SAM, *value added* is distributed through the factors of production to household owners of factors. The two factors of production have been sectorized out for SAM: (1) labor, and (2) all other factors aggregated into “Capital.” In this SAM, the total value added allocated to Labor is \$678.30 billion and to Capital, \$488.05 billion. The factor sectors, in turn, pay the factor income to households both inside and outside of California.

1.4. The Household Sectors

Households have a number of functions in the economy: they receive income from value added; they consume goods and services; they save and invest; and they pay taxes. In the sectoring of households for the SAM, each of these functions must be represented. However, because Senate Bill 1837² specifies that a complete dynamic analysis must examine taxpayers' behavioral response to changes in taxes, the primary criterion for household sectoring is household tax status. For this SAM, eight household sectors are delineated. These sectors correspond to the marginal tax brackets specified in the California tax code, with the addition of a high-income household.

Sectoring of households according to their primary wage earner's marginal tax bracket not only distinguishes the households for tax purposes, but it also results in a grouping of households according to income levels. A grouping of households by income allows the modeler to distinguish consumption and income patterns among income levels. The household sectoring was accomplished using the Franchise Tax Board stratified sample data to obtain the distribution of wages and other income by marginal tax rate for California Personal Income Tax data for 2000. This information was used to produce a percentage distribution of factor payments generated by industrial and government sectors to the eight household groups.

The sectors are delineated by marginal tax rate so that sector "9.3 MT" delineates the household group subject to a marginal tax rate of 9.3%.

1.5. The Investment Sector

In economic theory, *investment* is a purchase of goods and services augmenting the capital stock. Capital stocks by industry are imputed for SAM by assuming that the economy was initially in equilibrium and by using published values for average rates of return by industry. Assuming a 5% depreciation rate, a gross investment value by destination of investment for the 92 industrial sectors of SAM is imputed.

² Senate Bill 1837 (SB 1837, Campbell, Chapter 383, and Statutes of 1994).

These estimates of imputed gross investment are combined with an industry share matrix calculated from the most current (1997) BEA matrix of capital purchases by source and destination for the United States. The share matrix is an ancillary file prepared along with this SAM. Combining the share matrix, which identifies how a dollar of gross investment made by an industry is distributed across the source industries, with the imputed gross investment estimates resulted in a matrix of investment demand by source.

A series of assumptions are incorporated in the SAM investment calculations. To the extent that the economy is not in equilibrium in the base year, the levels of investment will be misrepresented. To the extent that the distribution of investment sources has changed since 1997, further misrepresentation is introduced. However, the gains from reflecting with precision how an investment decision in one sector results in investment demand in other sectors would appear to outweigh these potential sources of error.

1.6. The Government Sectors

A purpose of the SAM is to analyze the dynamics of California state revenue. However, the SAM must account for government expenditure in order to trace any feedback effect to state revenue from changing demand for goods, services, and factors as expenditure changes. Further, some elements of government (such as Cal Trans) are mandated to change their expenditures as their revenue changes, and the state's expenditure distribution between education and other items is controlled by Proposition 98.

As a result of these considerations, government sectors must be organized so that both revenue flows and expenditure flows can be traced explicitly. The major government revenues are taxes, sales of services, and intergovernmental transfers. The major government expenditures are the purchase of goods and services, transfer payments to households, wages, and intergovernmental transfers. Federal, state, and local governments all engage in revenue collection and expenditure, and all three levels of government are represented in SAM. California state government revenue and taxation receive the greatest scrutiny, while federal and local governments are held primarily exogenous to the model.

For the SAM, 36 government sectors representing federal, state, and local governments have been created. This sectoring allows the modeler to trace explicitly the major government expenditure and revenue flows. A description of the criteria and sectoring for each level of government follows. The sectoring of the government sectors is nearly the same as in the original SAM; the change from the original SAM is the inclusion of additional detail on state government.

1.6.1. Federal-Government Sectoring

To model the federal government for the purposes of SAM, seven federal government sectors are created: five to account for federal government revenue flows and two to account for federal government expenditure flows. The primary sources of revenue for the federal government are personal income tax, corporation income tax, social insurance taxes, excise taxes, estate and gift taxes, and customs duties.

Federal government expenditure is divided into two sectors to separate the pattern of defense expenditures (goods and service acquisition from particular sectors and rental of labor) from the rest of the federal government's expenditures in California (transfer payments to individuals, intergovernmental transfer payments, purchases of goods and services, and factor rentals).

Note that most elements of the federal government are exogenous to California. Taxation rates, purchases of goods and services, and rental of factors are fixed in real terms, though nominal expenditures are allowed to change in response to prices. Transfer payments to individuals (Social Security and federal pensions) are fixed in per-household nominal terms with the number of households receiving these held at a fixed fraction of non-working households derived from analysis of tax sample data. The federal government sectors are described in detail below.

1.6.1.1. Social Security (FTSOC)

This is the social-security component of federal revenues. The primary source of payments made by industries, households, and other governments to FTSOC is California Department of Finance (DOF) personal income data estimates. The primary source of the distribution of payments from FTSOC is the Franchise Tax Board's (FTB's) stratified tax sample for year 2000.

1.6.1.2. Personal Income Tax (FTPIT)

This is the personal income tax component of federal revenues. Data for federal personal income taxes are from Internal Revenue Service (IRS) data stratified by FTB staff and made available to DOF. These data are allocated according to SAM household types. Discrepancies between federal and state tax tables are accommodated by applying an overall correcting constant to each household type's tax calculation to return estimates of actual taxes received. It is important to note that the model explicitly accounts for the deductibility of state and local taxes from federal incomes subject to taxes. The FTB-supplied average rates of itemized deductions are used for each household type.

1.6.1.3. Corporation Tax (FTPPO)

The FTPPO is the corporation tax component of federal revenues. It is taken from the IRS 2002 Data Book, updated by 9%, and then allocated to Payments to Capital line of the Industry I/O matrix.

1.6.1.4. Duties (FTDUT)

Non-sector specific excise tax (FTDUT) was allocated on Payments to Capital for goods-producing industries, only. This is the import duty tax component of federal revenues. Import and export data for regional economies are quite poor in detail. One major problem with the data is the lack of ability to distinguish which items are simply passing through the state en route to a final destination.

1.6.1.5. Miscellaneous (FTMSC)

This is the miscellaneous tax component of federal revenues. All other federal taxes are grouped into the miscellaneous component. Of this aggregation, excise taxes on tobacco, alcohol, and liquid fuels are the major taxes. The others are distributed across the rest of the industrial sectors by their percentage share of domestic demand.

1.6.1.6. Federal Nondefense Spending (FSNON)

This sector accounts for federal non-defense spending and receives its income from the five federal revenue sectors. Its expenditures are of two kinds: purchases and transfers. The purchases are of goods and services and the factors of production, labor, and capital. The intergovernmental transfers are to FSDEF (defense spending), California expenditure units, and local expenditure units. Published summaries of local

government revenue and expenditure combined with the state's budget summary identifies the destination of all but FSDEF transfers. The FSDEF transfers are made equal to FSDEF expenditures.

Although not fully implemented at the federal level, it is assumed that all intergovernmental transfers from the federal government to California and local governments are block grants.³ Given the indirect relationship between liquid fuels taxes and transfers for transportation and the thrust at the federal level to turn all health and human services into block grants, this seems a reasonable assumption. In making this assumption, any connection between economic activity in California and federal grants to California and local governments is ignored.

1.6.1.7. Federal Defense Spending (FSDEF)

This sector accounts for federal defense spending. An intergovernmental transfer from FSNON to FSDEF is established to equal the total of expenditures.

1.6.2. State Government Sectoring

In order to model the California State government for the purposes of DRAM, 27 state government sectors are created: Twenty to account for government revenue flows and seven to account for government expenditure flows.

State revenues are collected into three types of funds: (1) the General Fund, (2) Special Funds, and (3) Non-governmental Funds. The General Fund is the largest government accounting unit. Most taxes and fees that are collected without a specific expenditure allocation are deposited into the General Fund. Revenue collected from special taxes, fees, or revenue designated to a specific expenditure destination are collected through Special Funds. Non-governmental funds are managed by the State of California but are off-budget items. Two non-governmental funds (unemployment/disability insurance and workers' compensation) are explicitly modeled in SAM. State revenues are also augmented by federal funds. These are a source of income for California but are

³ A block grant is an unrestricted federal grant.

counted as intergovernment transfers. All California state government revenue details are extracted from the California State statistics.

The units for California revenue and expenditure are best summarized in table form, with Table 1.5 identifying the sources of revenues and Table 1.6 identifying how expenditures are grouped in SAM.

Table 1.5: California Revenue-Receiving Units in SAM

Sector	Name
CTHHS	VARIOUS HOUSEHOLD TAXES
CTBOZ	ALCOHOL TAXES
CTCIG	CIGARETTE TAXES
CTHOR	HORSE RACING
CTEST	ESTATE TAXES
CTTRL	TRAILER FEES
CTLIC	MOTOR VEHICLE LICENSE FEES
CTDIE	DIESEL FUEL TAXES
CTREG	MOTOR VEHICLE REGISTRATION FEES
CTMSC	MISCELLANEOUS
CTINS	INSURANCE GROSS PREMIUM TAX
CTGAS	GASOLINE FUEL TAXES
CTSAU	SALES AND USE TAXES
CTBAC	BANK AND CORPORATION TAX
CTLAB	LABOR TAXES UI AND WORKERS COMP
CTPIT	PERSONAL INCOME TAX
CTRGU	REGULATORY LICENSES AND FEES
CT SVC	SERVICES TO THE PUBLIC
CTPAM	USE OF PROPERTY AND MONEY
CGENF	GENERAL FUND

One revenue account, CGENF (General Fund), deserves special mention. This account receives transfers from revenue units according to proportions reported in the Budget Summary. The general fund transfers money to other spending units and directly funds state programs such as education.

Table 1.6: California Expenditure Units

Model Sector	Major Departments	Major Sources of Revenue	Expenditure
CSTRA	Cal Trans, CHP	Highway Users Taxes Motor-Vehicle Fees	Engineering Services Construction Transfers to Local Gov'ts
CSCOR	Youth and Adult Correction Agency	General Tax Revenue	Labor Goods & Services
CSK14	Education	General Tax Revenue	Transfers to Local Gov'ts
CSUNI	Higher Education	General Tax Revenue	Labor Goods & Services
CSWEL CSHTH	Health and Welfare	General Tax Revenue Transfers from USA	Transfers to Households and Local Gov'ts
CSOTH	Legislative, Judicial, Executive, State and Consumer Services, Business, Housing, Trade and Commerce, Resources, General Government	General Tax Revenue Special Funds subvned to Local Governments	Rental of Factors Goods & Services Transfers to Local Gov'ts

Education is funded according to Proposition 98. Proposition 98 requires that educational spending increase as a consequence of increasing average daily attendance, personal income, General Fund revenues or transfer payments. There are two forms of the Proposition 98 rule, called the Test 2 and Test 3 forms. When Test 2 is applied, a transfer from CGENF to LSK14 education is made in amounts proportionate to previous transfers updated by changes in average daily attendance and per-capita personal

income. Test 3 mandates a transfer in proportion to changes in average daily attendance and per-capita General-Fund revenues. Without belaboring the details of Proposition 98, the choice of Test 2 or 3 is more of a public choice decision than an economic one. The CGE model that was built from this SAM accounts for these flows and can accommodate either decision.

For each expenditure unit, published summaries of expenditures are consulted to obtain the most precise distribution of these expenditures across SAM's industry, factor, and household sectors.

1.6.3. Local Government Sectoring

Because local governments are exogenous to this study's model, their level of detail in SAM is minimized. As with federal units, the major sources of local revenue and expenditures from published reports (relying generally on the series of *Financial Transactions Concerning...* annual reports issued by the Controller's Office for Cities, Counties and other local governmental units) are identified. The local revenue sources fall into four categories: (1) property taxes, (2) fees, (3) miscellaneous revenues, and (4) intergovernmental transfers from the federal government and California. The sectoring of local government revenue agencies reflects these sources. Local government expenditure agencies are sectoried according to expenditures on sectors such as transportation, corrections and legal affairs, education, health and welfare, and more. A description of each of the local government sectors is given below.

1.6.3.1. Local Property Tax (LTPRP)

Many local entities, such as counties, cities, and special districts, have the legal authority to levy taxes on certain real property. With the advent of tax reform in the 1970s (such as Proposition 13), these revenues have fallen to about a quarter of local government revenues.

Because the taxed value of property has a limited relationship to market prices and because no data appear to exist to properly identify the value of real estate by industry or household type, the overall level of property tax revenue by all local governments is identified and treated as a per-working household tax and as an excise tax on business.

The per-household rate is set proportionate to incomes in the base data but not allowed to vary in the model from these levels.

1.6.3.2. Government Local Tax Sales And Use (LTSAU)

This is the local government share of the sales tax and use taxes.

1.6.3.3. Government Local Tax Miscellaneous On Firms (LTFMS)

These are other taxes levied by local governments on firms.

1.6.3.4. Government Local Tax Miscellaneous On Households (LTHHS)

These are other taxes levied by local governments on households.

1.6.3.5. Local Miscellaneous (LTMSC)

Local governments operate some utilities at a profit, generate profits from other business-type activities, and have other minor sources of income. Although not a major source of local governmental revenues, these are included as a separate “taxing” authority of local governments.

1.6.3.6. Local Transportation (LSTRA)

Transportation is a key element of expenditure at the local level. Other sources of revenue account for only about one-half of the revenue for transportation.

1.6.3.7. Local Corrections (LSCOR)

Local Corrections, including courts, are established to reflect the state’s pattern of expenditures.

1.6.3.8. Local Kindergarten Through 14 (LSK14)

The LSK14 expenditures total over \$80.73 billion. Approximately one-half of these expenditures are funded by California intergovernmental transfers that are guided by Proposition 98. The remainder of revenues is from local property taxes and other local revenues.

1.6.3.9. Local Welfare (LSWEL)

Local spending for Welfare totals over \$16.37 billion.

1.6.3.10. Local Health (LSHTH)

Local spending for Health totals over \$8.36 billion.

1.6.3.11. Local Other (LSOTH)

The remainder of local governments is aggregated into this Local Other grouping. Policing, Fire, Utilities, Refuse, and Parks and Recreation form the majority of this sector. Revenue and expenditure not specifically allocated to other local governments and identified in published reports is allocated to LTMSC (Local Miscellaneous).

1.7. The Rest of World Sector

California has a large, complex economy that maintains trading relationships with other regional economies in the United States and other countries. In SAM, economic activity outside of California is modeled as a single economic unit. Thus, a household in Ohio buying California's oranges is as foreign as a firm in Osaka buying circuit boards built in San Jose. It is assumed that, like in California, households and firms outside California maximize utility and profits. California exports to Ohio or Osaka compete with local production in those economies and with goods and services produced elsewhere in the world.

Finding reliable data for these exports and for imports from the rest of the United States or the rest of the world is not possible. Foreign trade statistics are notoriously weak. Exports from Pacific ports in California are only partially documented as to their original sources, and transshipments through California for export are frequently identified as exports from California. Imports arriving in California's ports are documented even more poorly as to their final destination. Trade between California and the rest of the United States attracts no usable documentation for trade analysis purposes. With the advent of the North American Free Trade Agreement (NAFTA), the already limited documentation of trade between California and two of its three largest bilateral trade partners (Mexico and Canada) is deteriorating.

Faced with weak and unreliable data, SAM relies on the IMPLAN® economic impact modeling system as the primary source for trade data. The IMPLAN model contains estimates of interstate and international trade by 528 sectors. These sectors are

aggregated into SAM industry sectors. Completion of SAM involved ad-hoc balancing of the payments to and from the industry sectors using import and export values. Trade equals production minus consumption.

The levels of imports and exports are singularly the weakest and least supportable data of SAM.

This concludes the discussion of the major features of the SAM. This SAM is the most complete description of transactions in 2003 in the State of California. It has been rectified to reflect the energy flows reported by the Energy Information Administration (EIA), by sector—and so provides the perfect base on which to construct models of the California economy. It is particularly suited to model the effects of pollution control and energy policy on California.

2.0 Model Overview

Models of the kind used here have been applied to climate change in the past, and to the California economy in other contexts. Indeed, the CGE model is related to a model developed several years ago for the California Department of Finance.⁴ This being said, it is still useful to make explicit the relevance of this approach in the present context. The model is more extensively discussed in an annex below and its technical structure fully documented elsewhere, but a few general comments will facilitate discussion and interpretation of the scenario results that follow.

Why use an economic model?

Most human-induced environmental change originates in economic activity. Environmental effects of policy will largely result from economic responses. Thus, to understand environmental incidence, we need to understand economic behavior.

Why a California State model?

There are many alternative models of energy, environment, and the economy—most of them at the national level. Although these models can provide some useful inference for state policy makers and private stakeholders, California’s economy is unique. Moreover, national assessment masks extensive interstate spillovers and trade-offs, yet within-state adjustments are the ultimate metric by which we judge our own policy makers. The sheer size of the California economy also mandates dedicated modeling resources. As one of the world’s ten largest economies, surely California needs state-of-the-art research capacity to support its own policy design, implementation, and assessment.

Why a general equilibrium model?

The complexities of today’s economy make it unlikely that policy makers relying on intuition or rules-of-thumb will achieve anything approaching optimality when devising and implementing sectoral policy. Market interactions are so complex in

⁴ See Berck et al. (1996) and Berck (2000) for documentation of the DRAM and EDRAM models. These and the CGE model evolved from the same academic research model—a U.S. CGE developed in the 1980s.

determining economic outcomes that more sophisticated empirical research tools are needed to improve visibility for both public and private sector decision makers. The preferred tool for detailed empirical analysis of economic policy is now the Calibrated or Computable General Equilibrium (CGE) model.⁵ It is well suited to fiscal, sectoral, and environmental analysis because it can trace structural adjustments within the economy and elucidate market interactions, behavioral responses, and detailed incidence.

Beyond this, linkage effects are an essential determinant of the ultimate effects of policy, and cumulative indirect effects of policies often outweigh direct effects. Finally, there is the question of political sustainability. Economic policy may be made from the top down, but the political consequences of economic activity are ultimately felt from the bottom up. Stakeholders must be identifiable and their interests assessed so winners can be recruited in support of policy and losers' adjustment needs can be anticipated.

General equilibrium (GE) models, supported by detailed data, can elucidate these linkages and improve visibility for policy makers. General equilibrium models capture detailed market and non-market interactions in a consistent empirical framework. Linkages between behavior, incentives, and policies reveal how patterns of demand, supply, and resource use change in response to external shocks and policy changes. For these reasons, simulation models of this kind are ideal for designing incentive-based adoption policies and improving visibility for policy makers about downstream economic effects of their decisions, before they are taken.

2.1. The Modeling Facility

The CGE model is part of a constellation of research tools and investigations, all directed at enriching understanding of economy-environment linkages with regard to California climate change. The schematics in Figures 2.1 and 2.2 describe the four generic components of the modeling facility and their interactions. This report gives primary

⁵ For further reading on this approach, see e.g., Dervis et al. 1982; and Francois and Reinert 1997.

attention to outputs of the CGE model, but extensions of this work over the next two years will elaborate the other three components.

1. **Emissions modeling.** Here we need to move beyond fixed coefficient emission modeling and capture more intrinsic relationships between technology, adoption, and energy and emission efficiency. We also need to model both emission characteristics and policies targeted to non-carbon dioxide (CO₂) gases.
2. **Energy sector modeling.** The primary object of interest here is the electricity sector, where we need more detailed treatment of generation and heterogeneity in technology, fuel mix, and other attributes that are relevant to GHG issues. Explicit account also needs to be taken of CHP technology and penetration. The Oil Refining sector may also warrant more detailed treatment.
3. **Extensions.** This generic category captures all the new issues and research innovations that will be addressed in future generations of the model. These include, but are not limited to:
 1. Renewables
 2. Carbon sequestration
 3. Location/mapping
 4. Learning by doing
 5. Urbanization and regionalization
 6. Integration of water and land resources
 7. Public health modeling—closing the economy/environment loop

Beyond these general extensions, the CGE model will act as an integrating platform for other research innovations in California Energy Commission projects, including econometric results on adoption and other component behavioral modeling.

Figure 2.1: Component Structure of the Modeling Facility

Development of the California modeling capacity is proceeding in four distinct component areas.

1. core CGE model
2. emissions module
3. electricity generation module
4. a separate component for developing extensions.

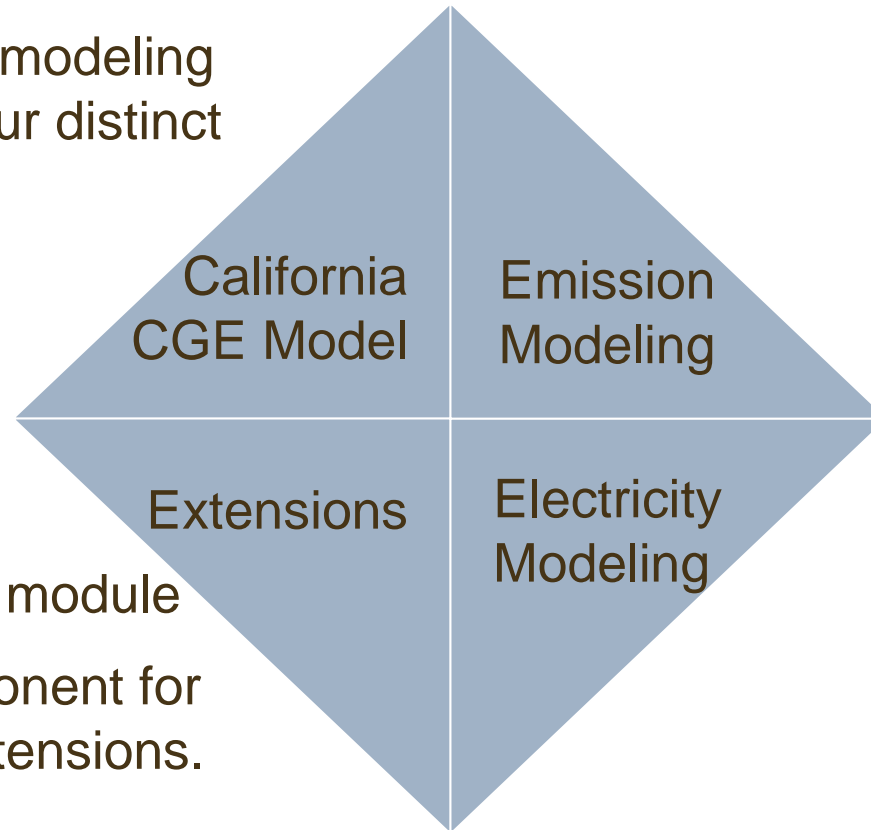
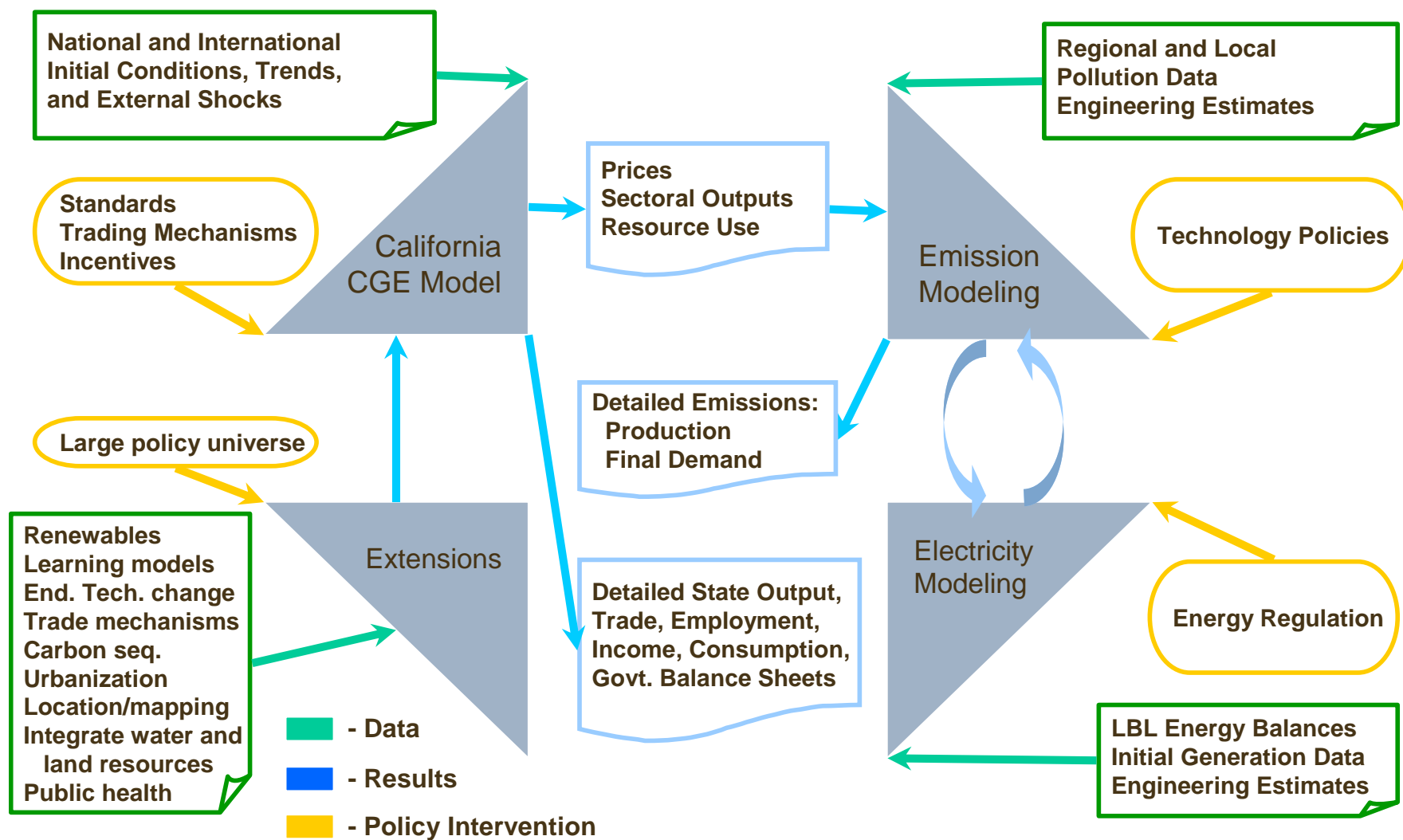


Figure 2.2: Schematic Linkage between Model Components



2.2. Structure of the CGE Model

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices—the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is precisely specified, equilibrium always exists and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economywide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes are not only substantial, but may in some cases even outweigh direct effects. Only a model that consistently specifies economywide interactions can fully assess the implications of economic policies or business strategies. In a multi-country model like the one used in this study, indirect effects include the trade linkages between countries and regions, which themselves can have policy implications.

The model used for this work has been constructed according to generally accepted specification standards, implemented in the GAMS programming language, and calibrated to

the new California SAM estimated for the year 2000.⁶ The result is a single country calibrated over a twenty-year time path from 2000 to 2020.⁷

This section provides a brief summary of the formal structure of the CGE model.⁸ For the purposes of this report, the California SAM was collapsed along certain dimensions. The current version of the model includes 20 sectors aggregated from the original 2003 California SAM. The equations of the model are completely documented elsewhere, but for the present, only its salient structural components are discussed.

2.2.1. Production

All sectors are assumed to operate under constant returns to scale and cost minimization. Production technology is modeled by a nesting of constant-elasticity-of-substitution (CES) functions.

In each period, the supply of primary factors—capital, land, and labor—is usually predetermined.⁹ The model includes adjustment rigidities. An important feature is the distinction between old and new capital goods. In addition, capital is assumed to be partially mobile, reflecting differences in the marketability of capital goods across sectors.¹⁰

Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply (zero-profit) conditions in all markets.

⁶ See e.g., www.gams.com.

⁷ The present specification is one of the most advanced examples of this empirical method, already applied to over 50 individual countries or combinations thereof (see e.g., Lee and Roland-Holst 1997).

⁸ See Roland-Holst (2004) for a complete model description.

⁹ Capital supply is to some extent influenced by the current period's level of investment.

¹⁰ For simplicity, it is assumed that old capital goods supplied in secondhand markets are homogeneous with new capital goods. This formulation makes it possible to introduce downward rigidities in the adjustment of capital without increasing excessively the number of equilibrium prices to be determined by the model (see Fullerton 1983).

2.2.2. Consumption and Closure Rule

All income generated by economic activity is assumed to be distributed to consumers. Each representative consumer allocates optimally his/her disposable income among the different commodities and saving. The consumption/saving decision is completely static: saving is treated as a “good” and its amount is determined simultaneously with the demand for the other commodities, the price of saving being set arbitrarily equal to the average price of consumer goods.

The government collects income taxes, indirect taxes on intermediate inputs, outputs, and consumer expenditures. The default closure of the model assumes that the government deficit/saving is exogenously specified.¹¹ The indirect tax schedule will shift to accommodate any changes in the balance between government revenues and government expenditures.

The current account surplus (deficit) is fixed in nominal terms. The counterpart of this imbalance is a net outflow (inflow) of capital, which is subtracted (added to) the domestic flow of saving. In each period, the model equates gross investment to net saving (equal to the sum of saving by households, the net budget position of the government and foreign capital inflows). This particular closure rule implies that investment is driven by saving.

2.2.3. Trade

Goods are assumed to be differentiated by region of origin. In other words, goods classified in the same sector are different according to whether they are produced domestically or imported. The degree of substitutability and import penetration shares are allowed to vary across commodities. A symmetric assumption is made on the export side where domestic producers are assumed to differentiate the domestic market and the export market.

¹¹ In the reference simulation, the real government fiscal balance converges (linearly) towards 0 by the final period of the simulation.

3.0 Dynamic Features and Calibration

The current version of the model has a simple recursive dynamic structure as agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities. Dynamics in the model originate in three sources: (1) accumulation of productive capital and labor growth; (2) shifts in production technology; and (3) the vintage capital specification of technology.

3.1. Capital Accumulation

In the aggregate, the basic capital accumulation function equates the current capital stock to the depreciated stock inherited from the previous period plus gross investment. However, at the sectoral level, the specific accumulation functions may differ because the demand for (old and new) capital can be less than the depreciated stock of old capital. In this case, the sector contracts over time by releasing old capital goods. Consequently, in each period, the new capital vintage available to expanding industries is equal to the sum of disinvested capital in contracting industries plus total saving generated by the economy, consistent with the closure rule of the model.

3.2. The Vintage Capital Specification of Technology

The substitution possibilities among production factors are assumed to be higher with the new capital vintages than with the old. Hence, when a shock to relative prices occurs (e.g., the imposition of an emissions tax), the demands for production factors adjust gradually to the long-run optimum because the substitution effects are delayed over time. The adjustment path depends on the values of the short-run elasticities of substitution and the replacement rate of capital. As the latter determines the pace at which new vintages are installed, the larger is the volume of new investment, the greater the possibility to achieve the long-run total amount of substitution among production factors.

3.3. Dynamic Calibration

The model is calibrated on exogenous growth rates of population, labor force, and Gross Domestic Product (GDP). In the so-called Baseline scenario, the dynamics are calibrated in each

region by imposing the assumption of a balanced growth path. This implies that the ratio between labor and capital (in efficiency units) is held constant over time.¹² When alternative scenarios around the baseline are simulated, the technical efficiency parameter is held constant, and the growth of capital is endogenously determined by the saving/investment relation.

¹² This involves computing in each period a measure of average (Harrod-neutral) technical progress in the capital-labor bundle as a residual.

4.0 Modeling Emissions

The CGE model captures emissions from production activities in agriculture, industry, and services, as well as in final demand and use of final goods (e.g., appliances and autos). This is done by calibrating emission functions to each of these activities that vary, depending upon the emission intensity of the inputs used for the activity in question. Each emission function corresponds implicitly to a technology of pollution, and the calibration procedure fits observed intensity levels to baseline activity levels.

The model has the capacity to track 14 categories of individual pollutants and consolidated emission indexes, each of which is listed in Table 4.1 below. The current study's main focus is GHG, but the other effluents are of relevance to a variety of environmental policy issues. This section briefly summarizes how emission activities are specified and how initial emission levels are calibrated. For more detail, please consult the full model documentation.

Equation 4.1 defines the total level of emissions for each pollutant p . The bulk of the pollution is assigned to the direct consumption of goods, which is the second term in the expression. The level of pollution associated with the consumption of each good is constant (across a row of the SAM) (i.e., there is no difference in the amount of pollution emitted per unit of consumption whether it is generated in production or in final demand consumption). The first term in Equation 4.2 represents *process pollution*. It is the residual amount of pollution in production that is not explained by the consumption of inputs. In the estimation procedure, a process dummy proved to be significant in certain sectors. If an emission tax (or taxes) are exogenous, they are specified in physical units, i.e., dollars per pound (or metric ton). Equation 3.2 converts this into a nominal amount.

The equations in Table 4.3 reproduce the corresponding equations in full model documentation, reflecting the pollution tax. The tax can be generated in one of two ways. It can either be specified exogenously (in which case it is multiplied by a price index to preserve the homogeneity of the model), or it can be generated endogenously by specifying a constraint on the level of emission. In the latter case, Equation 4.1 is used to define the pollution level constraint, and the tax which is generated by the constraint is the shadow price of Equation 4.1, and Equation 4.2 is not active.

Table 4.1: Emission Types**Air Pollutants**

1.	Methane (CH ₄)	CH4
2.	Nitrogen dioxide (NO ₂)	NO2
3.	Sulfur dioxide (SO ₂)	SO2
4.	Volatile organic compounds (VOC)	VOC
5.	Carbon monoxide (CO)	CO
6.	Suspended particulates	PART
7.	Toxic air index	TOXAIR
8.	Biological air index	BIOAIR

Water Pollutants

9.	Biochemical oxygen demand	BOD
10.	Total suspended solids	TSS
11.	Toxic water index	TOXWAT
12.	Biological water index	BIOWAT

Land Pollutants

13.	Toxic land index	TOXSOL
14.	Biological land index	BIOSOL

Table 4.2: Emission Level Equations

$E_p = \sum_i \nu_i^p X P_i + \sum_i \pi_i^p \left(\sum_j X A p_{ij} + \sum_h X A c_{ih} + \sum_f X A F D_f^i \right)$	(Equation 4.1)
$\tau_{Poll} = P \bar{\tau}_{Poll}$	(Equation 4.2)

The tax is implemented as an excise tax (i.e., it is implemented as a tax per unit of emission in the local currency). For example, in the United States, the tax would be the equivalent of \$x per metric ton of emission. It is converted to a price wedge on the consumption of the commodity

(as opposed to a tax on the emission), using the commodity-specific emission coefficient. For example, in Equation 4.3, the tax adds an additional price wedge between the unit cost of production exclusive of the pollution tax and the final unit cost of production. Let production equal 100 (million dollars for example), and let the amount of pollution be equal to 1 metric ton of emission per 10 million dollars of output. Then the total emission in this case is 10 metric tons. If the tax is equal to \$25 per ton of emission, the total tax bill for this sector is \$250. In Equation 4.1, ν might be equal to 0.1 (metric tons per million dollars of output), XP is equal to 100 (million dollars), while t_p is equal to \$25. Equation 4.4 takes account of the government revenue effect of pollution taxation.

Table 4.3: Emission Price Wedges

$$PQ_j XP_j = PX_j XP_j + \overline{ERSFP_j^f} - \sum_i \nu t x_i \left[PD_i^* XDp_{ij} + \overline{ERWPM_i} (1 + \tau_i^{m, Actv}) XMp_{ij} \right] \quad (\text{Equation 4.3})$$

$$GRev = MiscRev + Tax^h + \sum_p \tau_{Poll} E_p \quad (\text{Equation 4.4})$$

5.0 Data Resources for the Prototype Implementation

The CGE model is implemented with two primary datasets: (1) an aggregated and extended form of the California SAM described in Section 1 above, and (2) emissions data derived from diverse sources. These datasets represent the empirical foundation to which is calibrated a recursive dynamic CGE model and forecast interactions between economic events, pollution, and energy use.

For the prototype application presented in this study, the 2003 California SAM has been aggregated as indicated in the following table. Although this limits the ability to take full advantage of bottom-up engineering data that is targeted at more specific sectors, it was important for the sake of expedience in the current model development phase. Downstream, this study's researchers intend to explore more detailed sectoral policies and incidence analysis with the full resolution of the SAM data available.

The same argument applies to the spectrum of GHG gases considered. The preliminary results in this study look only at aggregate GHG emissions, including those from out-of-state electricity generation. In subsequent applications, the research team will detail non-CO₂ gases and have more explicit information about sources internalized in the model. Both these disaggregation strategies will support more detailed GHG policy analysis.

Finally, a high priority for the current phase of development is more detailed and explicit treatment of the electricity generation sector. To fully understand the patterns of adjustment across this industry and in the aggregate, it is important to more fully capture its diversity. This includes detailing generating capacity by size, technology, and vintage. In all three of these dimensions, policies can have highly variegated impacts, depending on the adjustment process. Later versions of the CGE model will take more complete account of the adjustment process and enable us to better understand the role of technological change, induced or otherwise. In addition to RPS, the research team is also working to incorporate CHP technology penetration, which can play an important role in future efficiency gains.

These data enable us to trace the effects of responses to climate change and other policies at unprecedented levels of detail, tracing linkages across the economy and clearly indicating the indirect benefits and tradeoffs that might result from comprehensive policies pollution taxes or

trading systems. As shown in the results section, the effects of climate policy can be quite complex. In particular, cumulative indirect effects often outweigh direct consequences, and affected groups are often far from the policy target group. For these reasons, it is essential for policy makers to anticipate linkage effects like those revealed in a general equilibrium model and dataset like the ones used here.

Table 5.1 illustrates the sectoring and other institutions used in this CGE application. It should be noted that the SAM used with the CGE departs in a few substantive respects from the original 2003 California SAM. The two main differences have to do with the structure of production (as reflected in the input-output accounts) and with consumption good aggregation. To specify production technology in the CGE model, these studies rely on both activity and commodity accounting; whereas, the original SAM has consolidated activity accounts. The research team chose to maintain separate activity and commodity accounts to maintain transparency in the technology of emissions and patterns of tax incidence. The difference is non-trivial and considerable additional effort was needed to reconcile use and make tables separately. This also facilitated the second SAM extension, however, where the team maintained final demand at the full 103 commodity level of aggregation, rather than adopting six aggregate commodities like the original SAM.

5.1. Emissions Data

Emissions data at a country and detailed level have rarely been collated. An extensive dataset for the United States exists that includes thirteen types of gas, liquid, and solid pollution emissions.¹³ The emission data for the United States has been collated for a set of over 400 industrial sectors. In most primary pollution databases, measured emissions are directly associated with the volume of output, which has several consequences. First, from a behavioral perspective, the only way to reduce emissions, with a given technology, is to reduce output. This obviously biases results by exaggerating the abatement-growth tradeoff and sends a misleading and unwelcome message to policy makers.

¹³ See Martin et al. (1991).

Table 5.1: Aggregate Accounts for the Prototype California CGE

20 Production Sectors and Commodity Groups	
1.	Agriculture
2.	Other Primary Products
3.	Oil, Gas, and other HC Fuels
4.	Distributed Electricity
5.	Distributed LP Gas
6.	Other Utilities
7.	Processed Food
8.	Residential Construction
9.	Other Construction
10.	Light Industry
11.	Resource-intensive Industry
12.	Machinery and Manufacturing
13.	Technology
14.	Electrical Appliances
15.	Automobiles
16.	Trucks
17.	Other Vehicles
18.	Wholesale and Retail Trade
19.	Transport Services
20.	Other Services
5 Factor Categories	
1.	Skilled Labor
2.	Unskilled Labor
3.	Capital
4.	Land
5.	Natural Resources
8 Household Groups (by income)	
1.	HOUS0 (< \$0k)
2.	HOUS1 (\$0–12k)
3.	HOUS2 (\$12–28k)
4.	HOUS4 (\$28–40k)
5.	HOUS6 (\$40–60k)
6.	HOUS8 (\$60–80k)
7.	HOUS9 (\$80–200k)
8.	HOUSH (\$200k+)
Enterprise Account	
External Trading Partners	
1.	ROUS Rest of United States
2.	ROW Rest of the World

More fundamentally, output-based pollution modeling fails to capture the observed pattern of abatement behavior. Generally, firms respond to abatement incentives and penalties in much more complex and sophisticated ways by varying internal conditions of production. These responses include varying the sources, quality, and composition of inputs; choice of technology; and more. The third shortcoming of the output approach is that it provides no guidance about other important pollution sources outside the production process, especially pollution in use of final goods. The most important example of this category is household consumption.

In an attempt to advance methodology in this area, the research team adopted a method that imputes observed pollution per unit of output to patterns of input use. Using the detailed California input-output table and national output-based emission coefficients, the team obtains input-based emission coefficients by the following relationship:

$$e_I = (AA')^{-1}Ae_O$$

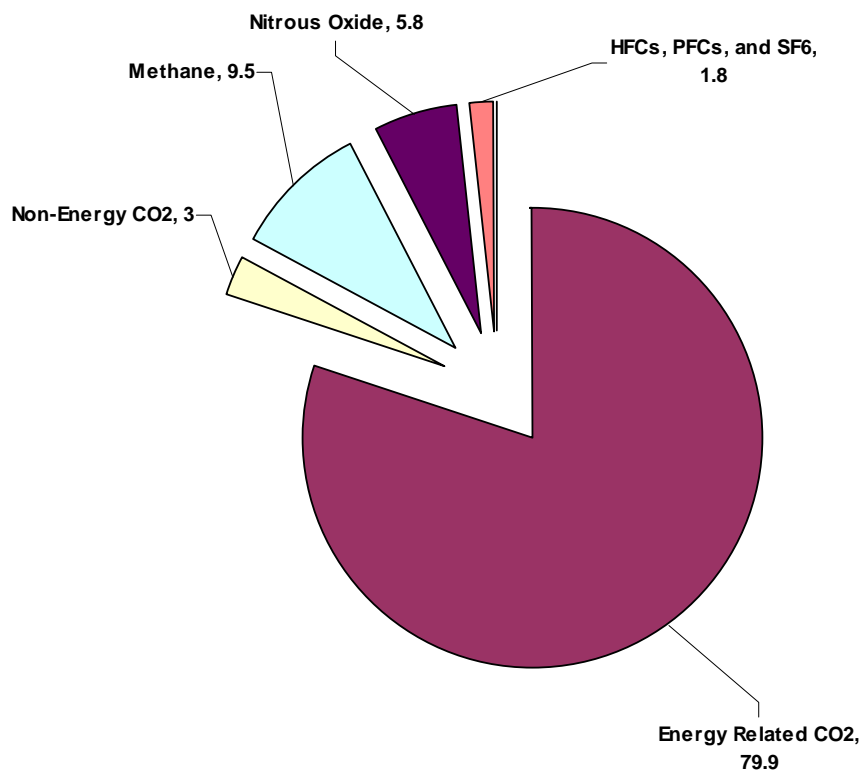
where e_O denotes emissions per unit of output (the base data), e_I denotes emissions per unit of input (the desired metric), and A is the conventional matrix of input use shares from the input-output table. Because this represents a standard statistical (linear regression) estimation, it is possible to evaluate the predictive characteristics of the imputation. In doing so for the 103x103 CommodityxActivity California use table, we find that the level of emissions can be explained by a very small subset of inputs.¹⁴ This allows producers to substitute away from polluting inputs, and moreover gives us a starting point for evaluating the role of pollution in consumption.

In the next generation of the CGE model, the research team plans to incorporate California-specific GHG emission estimates developed by Lawrence Berkeley National Laboratory (LBNL) with more intensively researched supply-chain emissions data from the Economic Input-Output Life-Cycle Assessment (EIO-LCA) Database of Carnegie Mellon University's Green Design Initiative (CMU-GDI 2004).

¹⁴ See Dessus et al. (1994).

5.2. Non-CO₂ Gases

Although this preliminary report focuses on aggregate GHG and CO₂ emissions, the CGE model is currently being extended to take account of other GHG categories. To see the importance of these gases in overall emissions, Figure 5.1 decomposes their shares for national emissions. Carbon dioxide from burning fossil fuels is the dominant GHG source category in the United States, typically comprising about 80% of all GHG emissions. However, other gases, particularly methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), are even more potent energy absorbers than CO₂ (per unit weight) and have cumulatively contributed between one-fifth and one-third of the total estimated global warming potential (GWP) since pre-industrial times. Therefore, capturing the effects of policies to reduce non-CO₂ GHG emissions is an important component of the proposed analysis.



Source: USDOE (2003)

Figure 5.1: National Average Composition of GHG Emissions, 2000 (%)

Table 5.2 summarizes the GWP of leading GHG types, using CO₂ energy absorption potential as the unit of measurement.

**Table 5.2: Global Warming Potentials
(100-Year Time Horizon)**

GAS	GWP
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	23
Nitrous oxide (N ₂ O)	296
Hydrofluorocarbons	
HFC-23	12,000
HFC-125	3,400
HFC-134a	1,300
HFC-143a	4,300
HFC-152a	120
HFC-227ea	3,500
HFC-43-10mee	1,500
Fully Fluorinated Species	
SF ₆	22,200
CF ₄	5,700
C ₂ F ₆	11,900
C ₄ F ₁₀	8,600
C ₆ F ₁₄	9,000

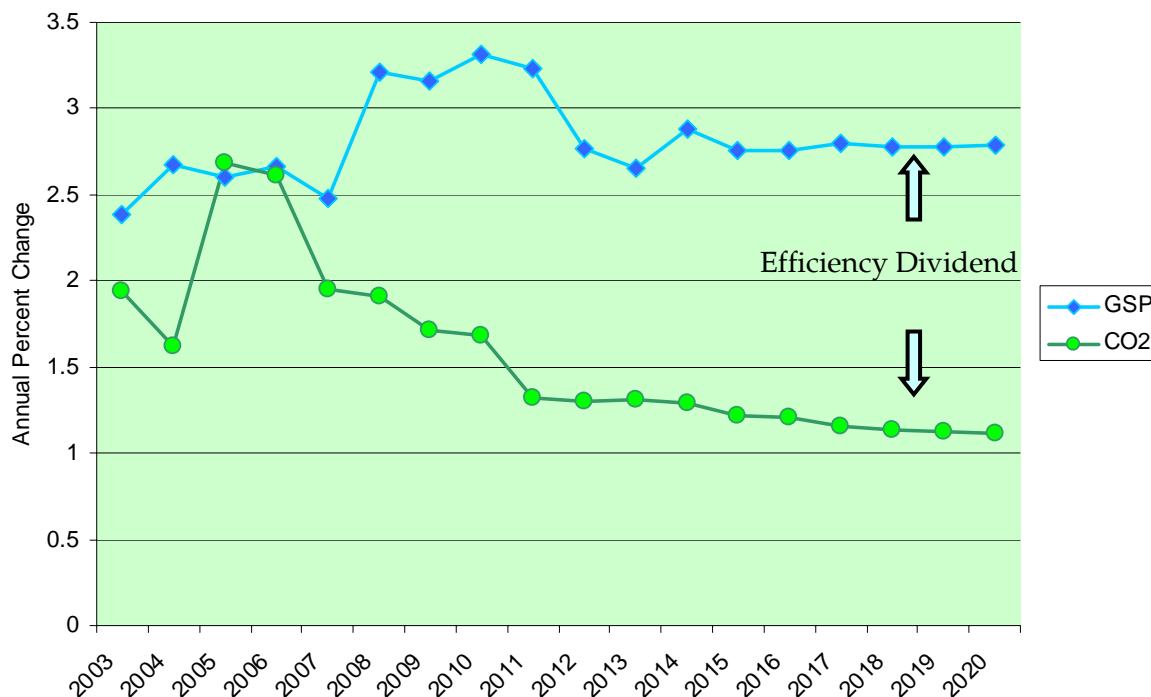
Source: DOE: <http://www.eia.doe.gov/oiaf/1605/gwp.html>

The concept of global warming potential was developed to compare the ability of each GHG to trap heat in the atmosphere relative to another gas. In this case, CO₂ is the reference case. Methane, for example, has a GWP of 23 over a 100-year period. This means that on a kilogram-for-kilogram basis, methane is 23 times more potent than CO₂ over a 100-year period.

6.0 Eight Policy Scenarios and Preliminary Results

As an illustrative exercise to demonstrate the capacity of the CGE model for policy research, this section sets forth eight generic scenarios for the state’s economic growth and structural change over the next 15 years (see Table 6.1). The first of these is the calibrated Baseline, which represents a “business as usual” scenario, holding the policy environment constant and moving forward at status quo aggregate growth rates. This Baseline is then used as the dynamic reference path for evaluating alternative policy initiatives and changing external conditions over the same period (2005–2020).

**Figure 6.1: Aggregate Economic and Emissions Trends:
California’s Efficiency Dividend**



This section briefly defines each scenario and presents the counterfactual simulation results in greater detail. This preliminary set of experiments focuses exclusively on aggregate GHG emissions. From the outset, it must be emphasized that all these results are preliminary and subject to change as data resources and the model specification advance. It should also be noted that references to scenarios, even when they include similar names and terminology, do not

imply a formal connection with official public policies or other private references using comparable terminology.

6.1. Baseline

This scenario provides reference or benchmark trends in economic and emission variables for evaluating counterfactual policy scenarios. As such, it should embody expectations about growth and structural change in a “business as usual” or status quo policy environment. The technique of baseline calibration is discussed in detail in Appendix B to this report, but for the moment, only the basic approach is summarized. Given the detailed economic situation calibrated to an initial year (2003), the model is run forward and constrained to hit annual macro targets for economic growth and emission levels. In the present exercise, the economic growth target is Gross State Product (GSP) forecast by the California Department of Finance, and the (GHG) emissions target is a baseline (do nothing) policy trend obtained from independent sources (Lazarus 2005).

It should be borne in mind that the Baseline represents only one set of assumptions about how future trends would involve without the policy interventions being considered. For example, there are diverse views about which steady state rates of technical innovation would achieve efficiency gains without further intervention. One of the chief advantages of a simulation framework like the CGE model is its ability to assess counterfactual policies against a variety of reference trends.

Detailed discussion of the economic and emission trends in the Baseline scenario could occupy a separate report, but the present discussion only references a few salient aggregate characteristics. In particular, it is important to compare assumptions that underlie the Baseline in terms of the emissions intensity of economic growth. Figure 6.1 displays annual percentage changes for GSP from DOF sources with annual percentage changes in aggregate CO₂ emissions in the Baseline, where the latter were input from independent sources as emission growth without new abatement policies or changes in per capita energy intensity.

Table 6.1: Prototype Scenarios

1.	Baseline Calibrated to DOF GSP and Exogenous GHG trends.
2.	CO2Cap A quantity restriction on statewide carbon dioxide emissions, coupled with an endogenously determined quantity premium (in the case of marketed pollution rights) or tax.
3.	CO2Tax Application of the tax rate resulting from the CO2Cap scenario, but with endogenous emissions.
4.	CapIno (Cap and Innovate) CO ₂ cap at scenario 2 level, GSP at baseline, endogenous carbon efficiency.
5.	Pavley A simulation of the Pavley Bill, which would mandate fuel efficient vehicles.
6.	EELR (Energy Efficiency in the Long Run) This scenario corresponds to state estimates (by Mike Messenger and others) of the public promotion costs and adoption benefits of promoting private energy efficiency.
7.	RPS (Renewable Portfolio Standard) Mandated substitution of renewable fuels in electricity generation.
8.	PV (Photovoltaic) A scenario for adoption of photovoltaic cells in residential and commercial construction.

Clearly, these two trends diverge over time, indicating a disparity that can only be reconciled by reductions in emissions intensity. Because the research team assumes that, in a scenario of positive economic growth, these reductions can only be achieved by increased innovation and adoption of technology, the divergence is referred to as California's "Efficiency Dividend."

The Efficiency Dividend means that, even in the "business as usual" Baseline scenario, improvements in emissions efficiency are implicit. These can take the form of increased adoption rates for existing technologies with above-average efficiency, innovation to produce

more efficient technologies, and combinations of these, but something like this will be necessary to reconcile the apparent divergence in GSP and GHG expectations.¹⁵

To put these aggregate growth disparities in perspective, a variety of trends in GHG growth are considered. Figure 6.2 presents three forward-looking series over the scenario interval, as well as one historical series for the last fourteen years. All results are here expressed as annual percentage changes in statewide GHG emissions. The series are defined as follows:

1. **Baseline.** Independent estimates of status quo GHG growth (defined above)
2. **CEC Reg.** Official projections of GHG trends, based on linear regression
3. **CEC Geo.** Official projections based on geometric mean extrapolation
4. **Historical (1990).** Actual statewide GHG emissions, with 1990 tied to 2004

While the Baseline GHG trend is broadly consistent with California Energy Commission (Energy Commission) projections according to one method, it diverges uniformly from the other. Thus, a reconciliation of the Energy Commission projections is needed before the plausibility of the Baseline numbers can be assessed. Finally, the historical trend is informative in two ways. First, it indicates how great is the variance in observed statewide GHG emissions, without shedding much light on why. Second, this variance itself indicates the challenges facing those who want to project aggregate annual emissions by any method. In summary, the Baseline GHG trend has been accepted as providing a workable reference trend, but the research team will engage in further work to advance this calibration exercise.

This subsection closes with some general trends in Baseline emissions. These are not exhaustive, but will give the reader a sense of relative magnitudes for different economic activities and institutions. First, Figure 6.3 displays initial shares of CO₂ emissions by generic economic activity, including both production and consumption behavior.

¹⁵ These scenarios and this discussion do not consider emission shifting, such as accelerated imports of out-of-state electricity and other emission-intensive goods and services.

Figure 6.2: Alternative Trends in Aggregate GHG Emissions

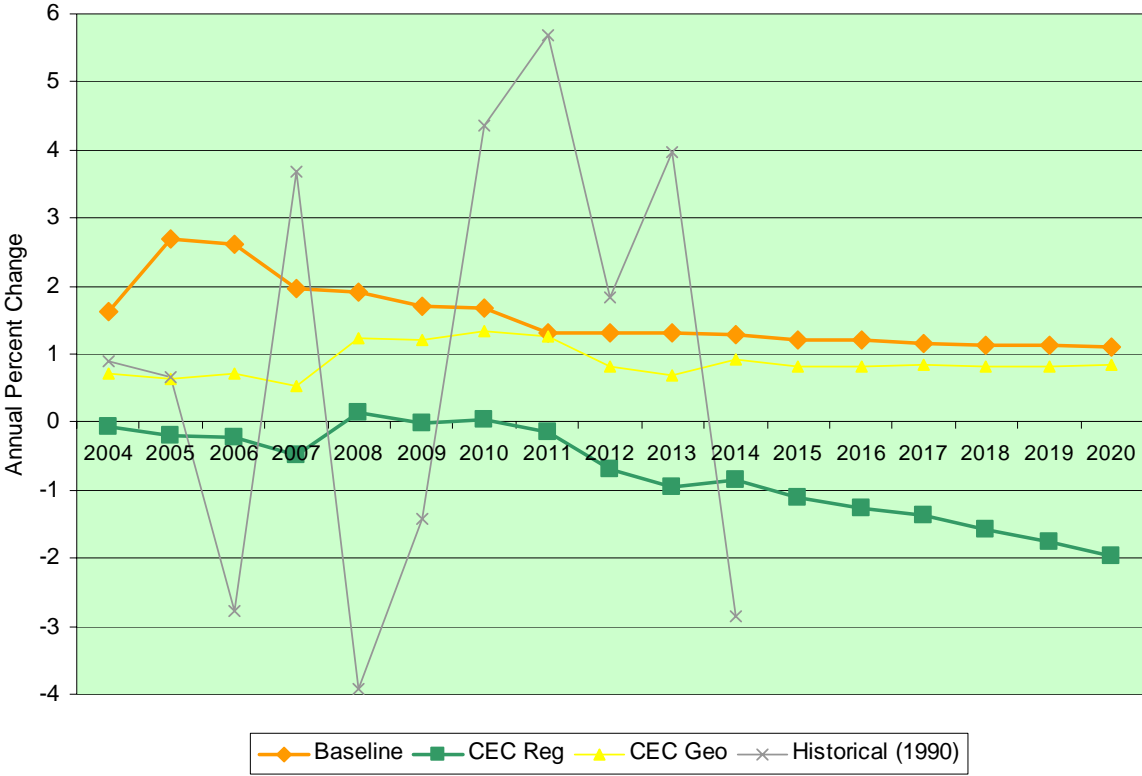
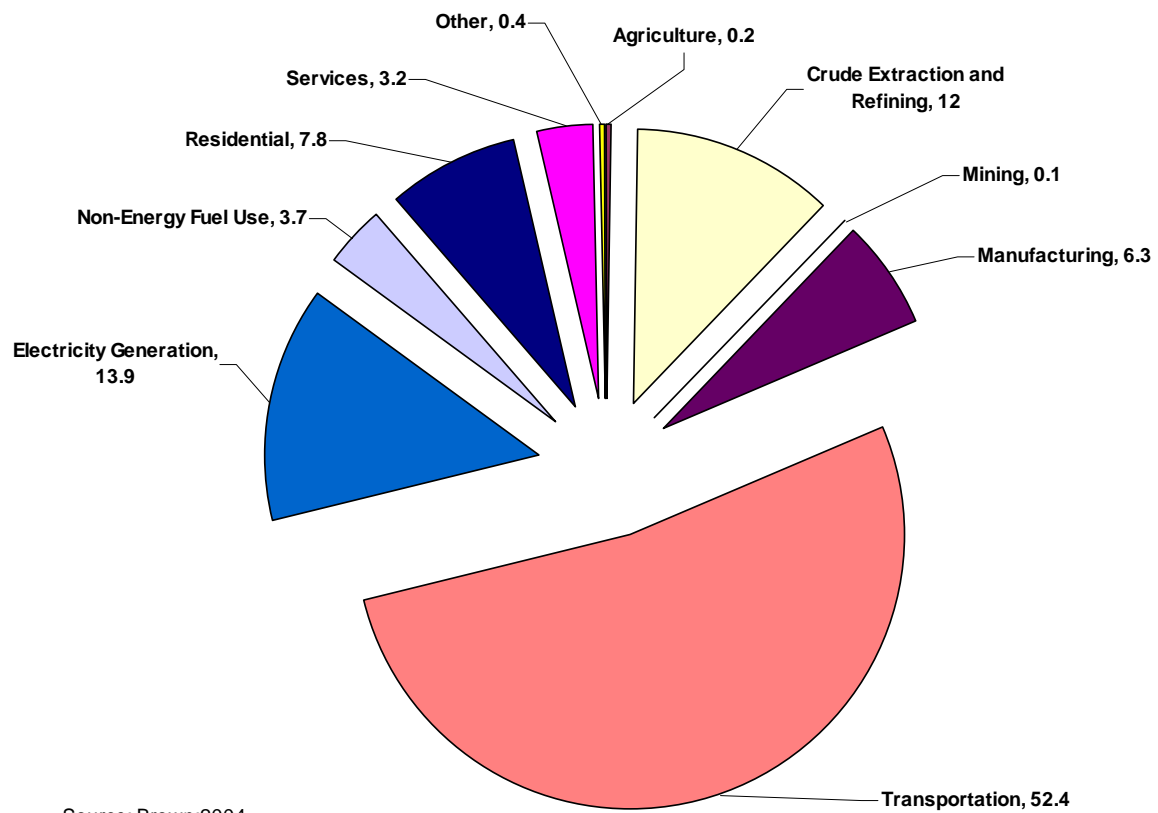


Figure 6.3: Components of CO₂ Emissions for California, 2000 (%)



Source: Brown:2004.

Figures 6.4 and 6.5 indicate how GHG emissions change over the Baseline time interval (2005–2020), disaggregating production activities (Figure 6.4) and households (Figure 6.5). Absent policy intervention or spontaneous adoption of more efficient technologies, both production and consumption patterns contribute to sustained increases in GHG emissions. Figures are in millions of metric ton coal equivalence.

**Figure 6.4: Total GHG Emissions by Sector
(in millions of metric ton coal equivalence)**

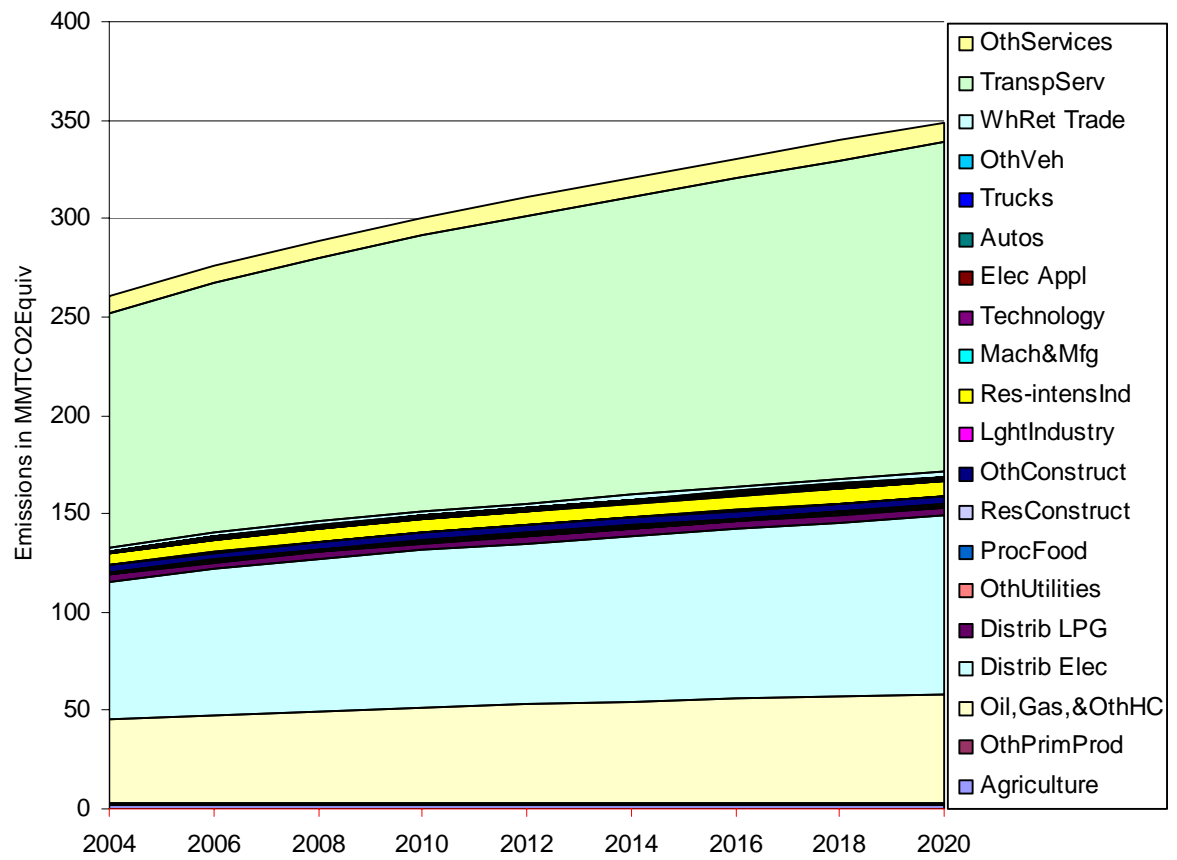
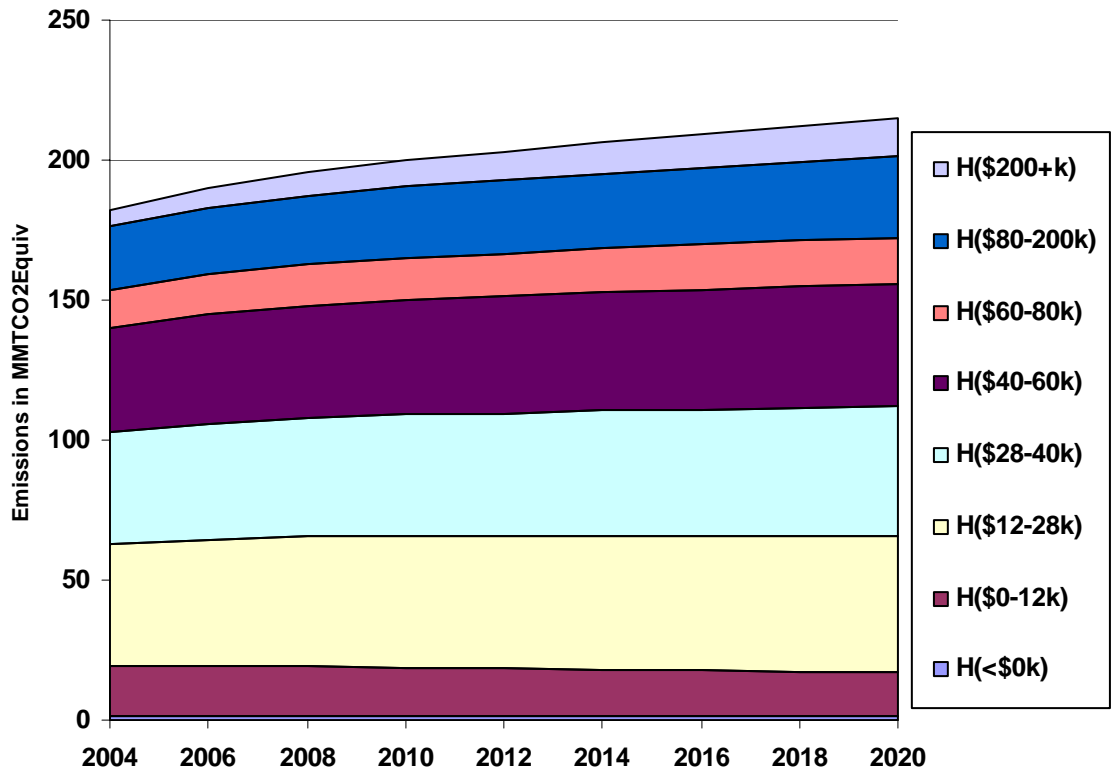


Figure 6.5: Total GHG Emissions by Households
(in millions of metric ton coal equivalence)



6.2. CO₂Cap

A quantity restriction on statewide CO₂ emissions, coupled with an endogenously determined quantity premium (in the case of marketed pollution rights) or tax.

This is the first of the abatement scenarios, representing a generic example of “cap-and-trade” mechanisms. Policies using these mechanisms generally impose a quantity target on total emissions and allocate permits to pollute by some mechanism, such as public auctions or giveaways. The fiscal components of such a program are complex, having mainly to do with how pollution rights, trading, and their fees are administered. The present application passes over these issues and looks only at assessing statewide changes in pollution patterns and economic performance.

Across a many dimensional continuum of alternative policy designs, we examine one that captures the main structural adjustments for the sake of illustration. In this scenario, industrial

CO₂ emissions are capped to achieve zero growth by the year 2020, phased continuously against Baseline trends from 2005 in equal proportional steps from the second year of the scenario interval to the last. Because of its general equilibrium structure, the model computes a price for emissions that would achieve the target aggregate levels in a marketable permit system. This market has many highly simplified properties, assuming that all agents buy permits to pollute at the same equilibrium price. This set-up actually corresponds to an annual auction of pollution rights to perfectly competitive bidders with the same information sets. Auction income accrues to government, there are no side-payments, and there are no other costs associated with pollution. The study also assumes that households have uniform pollution characteristics and identical preference within the eight categories given. Finally, no real technological change is included, apart from efficiency gains arising from changing economic structure. Counterpart GSP trends follow in Figure 6.6.

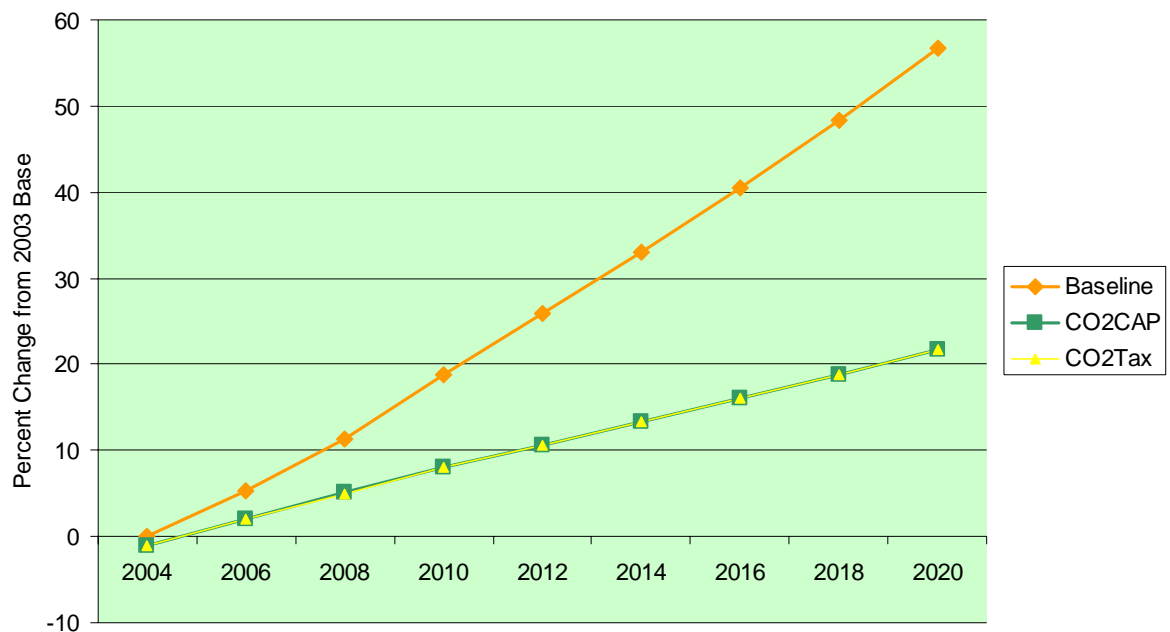


Figure 6.6: California GSP Trends: Baseline, CO₂ Cap and Trade, and CO₂ Tax

6.3. CO2Tax

Application of the tax rate resulting from the CO2Cap scenario, but with endogenous emissions.

The above figures actually represent three scenarios: (1) the Baseline, (2) the Cap-and-Trade experiment, and (3) its exact dual—an effluent tax equal to the pollution premium computed endogenously from the Cap-and-Trade System. The carbon premium or tax computed in this scenario was about \$90/Metric Ton (MT) of carbon equivalent. Recognizing that this tax would be the only instrument used in this scenario (no other exogenous or policy induced efficiency gains were assumed), this figure is broadly comparable with estimates discussed elsewhere. As is apparent from both scenarios, a significant reduction in aggregation GHG emissions, holding technology constant, will result in lower (but still positive) economic growth rates. Having said this, the abatement achieved is substantial, converting a 28% increase by 2020 into a 7% reduction. Note that in the case of the carbon tax, the terminal year tax is applied annually from the first year. This achieves additional abatement equal to the difference between the CO2Cap and CO2Tax trends over the scenario interval. Thus estimated, the cumulative opportunity cost of gradualist abatement policy is more than 100 million metric tons (MMT) of GHG.

Gross State Product still rises to over 20% by 2020, but under the Baseline, the corresponding figure is over 55%. Given this rather stark growth-environment tradeoff, it is reasonable to ask what level of efficiency would be required to hit both the GHG and Baseline GSP targets simultaneously. The third scenario provides a partial answer to this question, and the results indicate that ambitious but not unrealistic emission efficiency gains can sustain the two objectives in parallel.

6.4. CapIno (Cap and Innovate)

CO₂ cap at scenario 2 level, GSP at baseline, endogenous carbon efficiency.

This scenario poses the simple question: If we strive for both the Baseline GSP growth rates and the CO2Cap emission levels, what kind of emissions intensity improvements are needed? This is answered by fixing our two objectives exogenously and varying two more variables along the Baseline time path—namely the endogenous pollution fee and the aggregate rate of emissions per unit of GSP.

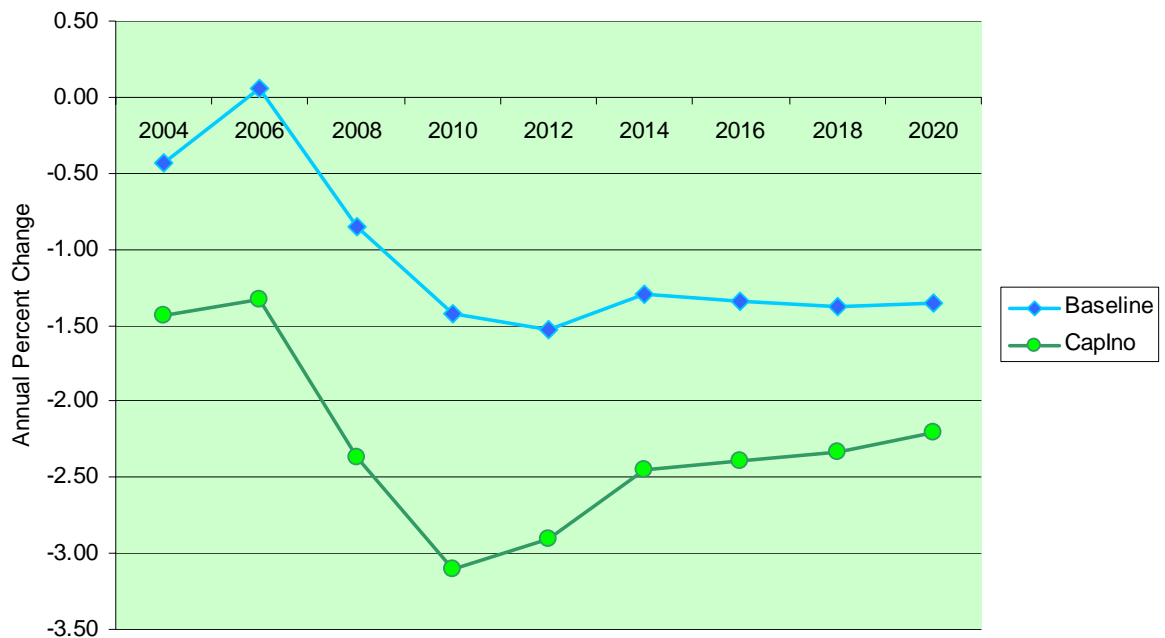


Figure 6.7: Rates of Change in Statewide Emissions Intensity (GSP/GHG)

The result of this exercise is encapsulated in Figure 6.7, which shows annual percentage changes in aggregate emission intensity (GSP/GHG) for the two scenarios. These results indicate that, to reconcile the state's Baseline growth aspirations with more sustainable CO₂ emission levels (i.e., returning to 2000 levels by 2020), innovation and adoption trends must support a 1%–1.5% reduction in aggregate GHG emission per unit of GSP. In the context of historical experience, this is an ambitious but not unrealistic goal. Thus it appears that growth and environmental objectives might be reconcilable, but these results do not offer specific guidance about how the additional efficiency can be achieved. The next four scenarios are intended to evaluate exactly such initiatives, among the leading ones in effect or under consideration at the moment.

6.5. Pavley

A simulation related to the Pavley Bill (AB 1493, Chapter 200, Statutes of 2002), which mandates minimum GHG vehicle emissions standards.

The most recent statewide initiative at GHG mitigation is a bill mandating new vehicle emission standards in California.¹⁶ This initiative, referred to in common parlance as the “Pavley Bill” requires automobile producers to import and sell more emission efficient vehicles. The direct effects of this policy are already being anticipated in a spirited debate between producer, consumer, and environmental interests, yet the ultimate economic impact is far more complex. Generally speaking, it is reasonable to expect that higher short-run costs associated with new vehicle acquisition would be offset by longer-run savings on automotive fuel (and perhaps other operating expenses). Because these two factors are very prominent economic variables, they will set in motion a complex series of adjustments across the automotive, energy, and related sectors, with the ultimate consequences for households depending on supply responses, demand patterns, and other structural adjustments. In other words, this policy sets in motion a classic general equilibrium adjustment process across the California economy.

The present scenario simulates the economywide implications of vehicle cost and fuel saving estimates obtained by the California Air Resources Board and reported in CalEPA 2004. Assuming that households incur both the higher vehicle cost and fuel savings in proportion to their incomes, the following main results were obtained:

1. Increased vehicle costs amount to an average surcharge of less than 6% on new vehicles.
2. Fuel cost reductions far outweigh the initial cost of more efficient vehicles, with payback periods averaging less than three years.
3. Gross State Product is not negatively impacted by this policy, with a slight benefit to the state as households shift their consumption in favor of more state-intensive goods and services.
4. Carbon mitigation under this program would be substantial, growing less than half as much as under the Baseline.

¹⁶ See CalEPA 2004 for details.

The microeconomics of this consumer choice decision have been analyzed in much greater detail in the draft CalEPA report, and this study's results bear out the conclusion that household operating cost savings significantly and rapidly outweigh adoption costs. The GSP effect is to be expected, because the research team is modeling adoption of an efficiency-improving technology and pecuniary benefits outweigh costs. The "in-state bonus" effect has also been mentioned by ARB analysts. In this case, more money is paid out of state to purchase new vehicles. This out-of-state expenditure leakage is offset by two other forces, however. The smaller of the two is a modest reduction in total auto demand, induced by rising average prices. More significantly, households take their operating cost savings (also import/fuel intensive) and reallocate them across their established consumption patterns. The latter are generally biased in favor of in-state services and commodities, so on the whole the consumption reallocation is more favorable to state production and employment.

Figures 6.8 and 6.9 present results for household GHG emissions and automotive fuel consumption, respectively. Clearly, adoption of a policy resembling the Pavley Bill could achieve very substantial GHG mitigation and contribute to more sustainable fuel consumption patterns. By 2020, the research team's calculations show that household GHG generation would be 44% below Baseline values, while fuel consumption would be 64% below the Baseline level in 2020, and both of these mitigations are achieved without adverse effects on aggregate growth. Finally, both levels would be significantly lower than they are today.

When interpreting these results, it must still be borne in mind that they are based on many assumptions, the most important being that the automotive stock is homogeneous in use and replacement. Most experienced observers expect Pavley to have more complex effects on auto demand and replacement patterns, and the present version of the model does not take account of these. Having conceded this, however, the research team believes that compositional effects are unlikely to reverse or even substantially diminish the estimated aggregate outcomes.

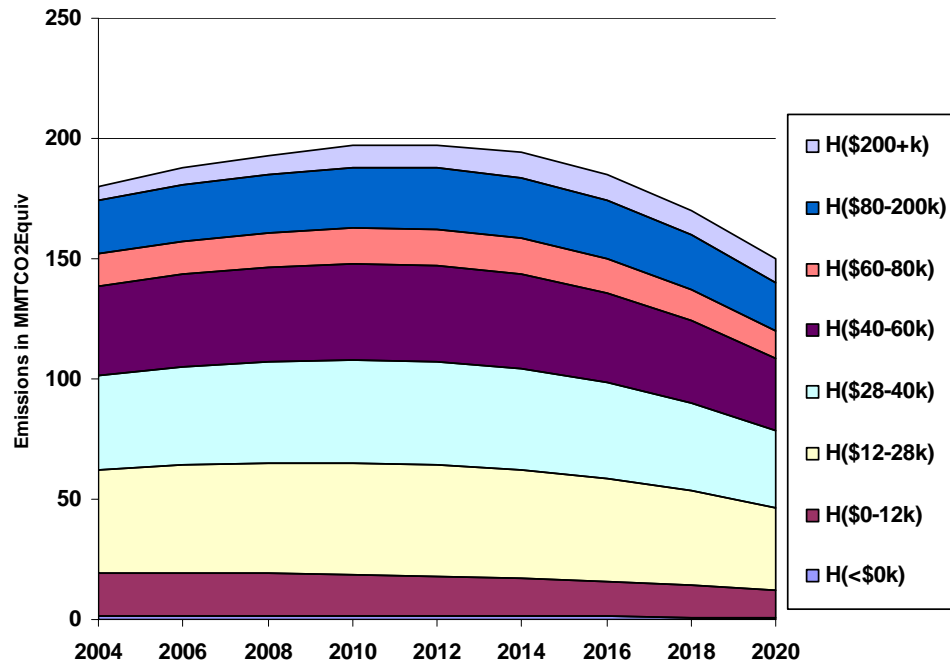


Figure 6.8: Household GHG Emissions

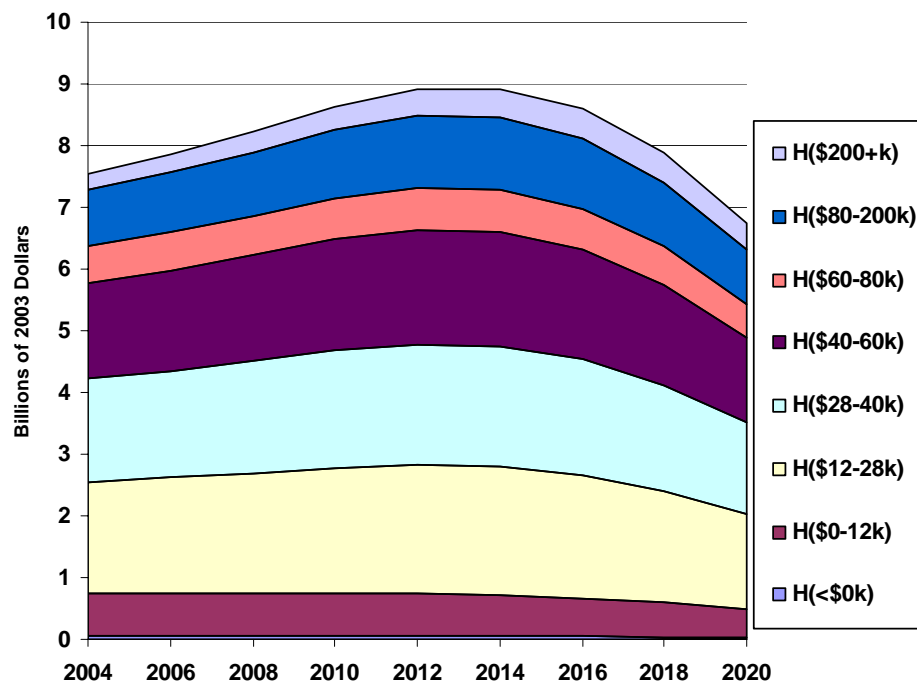


Figure 6.9: Household Automotive Fuel Use (Billion \$)

As a final note, Figure 6.10 reminds us that Pavley has only a very limited effect on emissions in production. It might be expected that, to the extent that vehicle use is an input to most sectors (especially transport services), we will see similar but more limited net benefits from Pavley in the production side of the economy. This is so, but the preponderance of GHG emissions continue forward on Baseline trajectories. By 2020, industrial GHG emissions are less than 3% below Baseline levels.

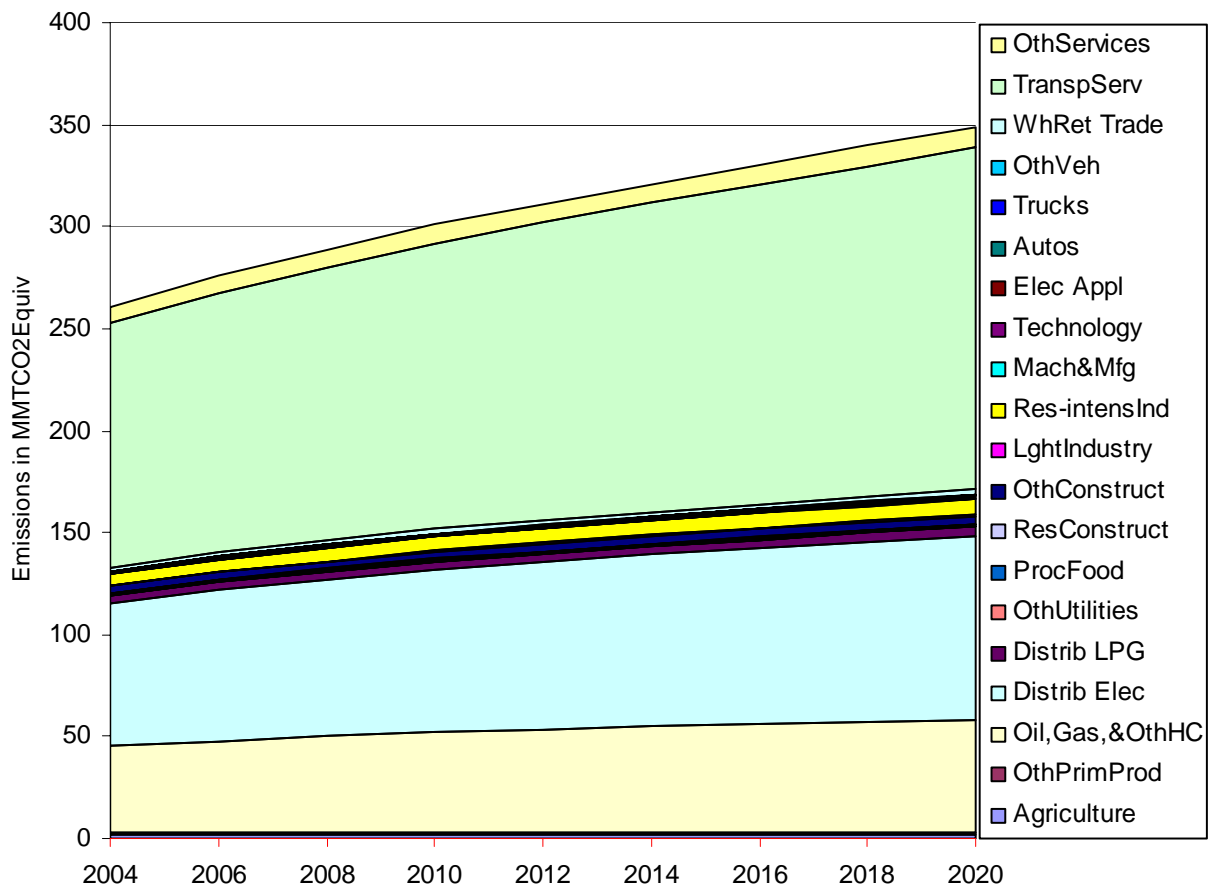


Figure 6.10: Sectoral GHG Emissions

6.6. EELR (Energy Efficiency in the Long Run)

This scenario corresponds to state estimates (by Mike Messenger and others; see Table 6.2 for details) of the public promotion costs and adoption benefits of promoting private energy efficiency.

The State of California is involved in a broad spectrum of public initiatives to promote energy conservation and more efficient energy use patterns. Although these are too numerous and diverse to be captured in a single scenario, the state has produced estimates of the aggregate relationship between public promotion expenses and private responses, and these provide a convenient reference to examining more comprehensive effects with a general equilibrium model. In particular, a recent study by Messenger (2003) for the Energy Commission has estimated alternative time paths of public expenditure for promoting energy efficiency and linked these to increases in private aggregate energy efficiency. These results give us the raw material for the EELR scenario.

More specifically, this scenario was constructed by interpolating Messenger's cost estimates annually from 2004, debiting this to the general fund state government account in the California SAM. On the energy use side, it is assumed that households achieve reductions in residential energy use by 1% per capita per annum, without specific reference to the technical means of this efficiency. All households reduce electricity demand by 1% per year against Baseline values, and it is further assumed that they experience no private adoption or other direct adjustment costs. Finally, the reduced expenditure on electricity is reallocated to other consumption in existing shares, with no net increase in private savings.

The basic macro results are consistent with what one would expect for modest efficiency and consumption reallocation—namely, moderate GHG reduction and negligible GSP effects. In particular, aggregate GHG grows by 22% over the 2005–2020 period rather than 28%, as in the Baseline. Although GHG only falls by about 6%, residential electricity demand is 28% lower than the Baseline by 2020. Extensions of the present work will go more deeply into the sectoral adjustments that would ensue for electricity.

Table 6.2: Program Data for EELR

	<i>Scenario</i>				
	<i>ELR1</i>	<i>ELR2</i>	<i>ELR3</i>	<i>ELR4</i>	<i>ELR5</i>
<i>Pecent Abatement</i>	0.16	-0.3	-0.5	-1	-1.5
<i>Year</i>	<i>Cost of Promotion (2003 millions)</i>				
2003	235	235	235	235	235
2004	235	274	274	342	428
2005	235	313	313	448	620
2006	235	352	352	555	813
2007	235	391	391	661	1,005
2008	235	430	430	768	1,198
2009	236	484	664	1,465	2,129
2010	237	538	898	2,162	3,060
2011	238	592	1,132	2,858	3,990
2012	239	646	1,366	3,555	4,921
2013	240	700	1,600	4,252	5,852
2014	240	700	1,600	4,252	5,852
2015	240	700	1,600	4,252	5,852
2016	240	700	1,600	4,252	5,852
2017	240	700	1,600	4,252	5,852
2018	240	700	1,600	4,252	5,852
2019	240	700	1,600	4,252	5,852
2020	240	700	1,600	4,252	5,852

Source: Messenger (2003)

6.7. RPS (Renewable Portfolio Standard)

Mandated substitution of renewable fuels in electricity generation.

Another state policy receiving attention in this area is the Renewable Portfolio Standard (RPS), which mandates fuel substitution (in favor of renewables) in electricity generation. More definitive treatment of this family of policies will be possible when the research team has elaborated its modeling of the electricity sector, but for the meantime, this section offers an illustrative scenario based on macro criteria. In particular, it is assumed that the sector generating electricity reduces its demand for fossil fuels 33% by 2020, phased in by equal percentage increments from 2004. Moreover, it is assumed that the alternative fuel is nonpolluting and is purchased from the general Service sector. Finally, it is assumed for convenience that no private adoption costs are associated with this fuel switching.

As the research team has modeled the RPS policy, the aggregate benefits are positive but really fairly small in magnitude. Gross State Product effects are negligible, GHG is reduced a few percentage points against the Baseline by 2020, and fossil fuel use for the state drops between 1% and 2% vis-à-vis the Baseline (27% growth against more than 28% by 2020). The main reason for these modest effects is that electricity generation consumes less than 13% of fossil fuels in the state, and reduced demand is partially offset by price declines increasing demand elsewhere.

It is reasonable to expect these results to constitute lower bounds for results obtained with a more extended model. The main reason for this is that heterogeneity of electricity capital stock will lead to retirement of more pollution and fuel-intensive generating capacity, magnifying the environmental gains from fuel substitution. The current scenarios assume constant energy prices, while rising prices can be expected to accelerate new technology adoption.

6.8. PV (Photovoltaic)

A scenario for adoption of photovoltaic cells in residential and commercial construction.

Another policy initiative that has gained prominence is promotion or regulation for large-scale adoption of PV cells in residential and commercial construction. Most such policies envision adoption in the construction of new dwellings or buildings rather than retrofitting, and the

effects of such a policy are simulated in this scenario. In particular, it is assumed that 50% of all new homes and offices adopt PV cells and that, in such structures, these cells provide for 50% of electricity. As an annual model, the ability to take account of load profiles and load-differentiated pricing is lacking, and moreover it is assumed that no net metering or other redistribution of the PV output occurs. Finally, it is assumed that the housing and office stock grow at the same rate and that adoption PV has the same fixed cost as electricity from conventional sources.

The results obtained for this scenario resemble those for EELR, in the sense that GDP effects are negligible and GHG effects are positive but modest. Even with very optimistic assumptions about PV supply (50%) to each end user's demand, we are still considering only a $.5 \times .5 = .25$ increment of capacity. With the housing/office stock growing at only about 1%–2% per year in California, the orders of magnitude between this policy and EELR are very similar.

Again, less stringent assumptions could increase the impact of this policy, including rising energy prices, peak load constraints, metering, and higher retrofit adoption rates. In any case, it should be borne in mind that most components of this adjustment, while small, are beneficial.

6.9. AllIn – All the above policies (including either CO2Cap or CO2Tax) taken together

An important advantage of the simulation approach to modeling is the ability to examine policies individually, isolating their effects, or in combination with others, identifying feedbacks, synergies, and discord between them. This section gives a simple example of this approach by including all the above policies in one scenario. The only one omitted was CO2CAP, which was superseded by CO2Tax, to keep emissions free to vary endogenously.

As might be expected, the AllIn scenario achieves the objectives of its components because all are generally trying to influence the same economic variables in the same directions. There do not appear to be significant synergies between the component policies, as the effects of AllIn are generally less than the sum of their parts. More detailed examination of these results will help reveal how the policies reinforce or offset one another, yet this combined approach holds significant promise in a context of very diverse constituencies and limits to effectiveness of very specific instruments. One size rarely fits all in the policy world, and blended approaches to even a narrow set of objectives is likely to be more broadly effective. It is hoped that more

sophisticated approaches that combine policies can achieve something closer to optimality. Overall results for AllIn are given in Figure 6.11 and Figure 6.12. Even with the very substantial GHG mitigation these policies occasion, total Household consumption is only 2.4% below the Baseline trend by 2020. This could be seen as a very small price to pay for sustained absolute reductions in GHG.

Figure 6.11: Household GHG Emissions

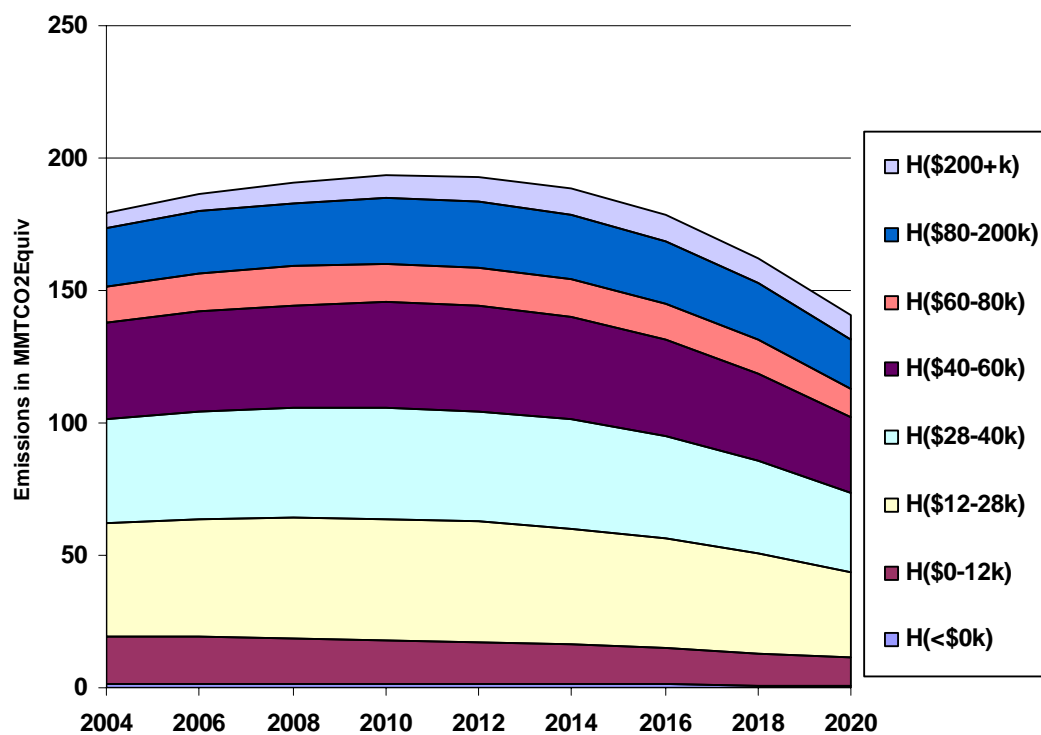
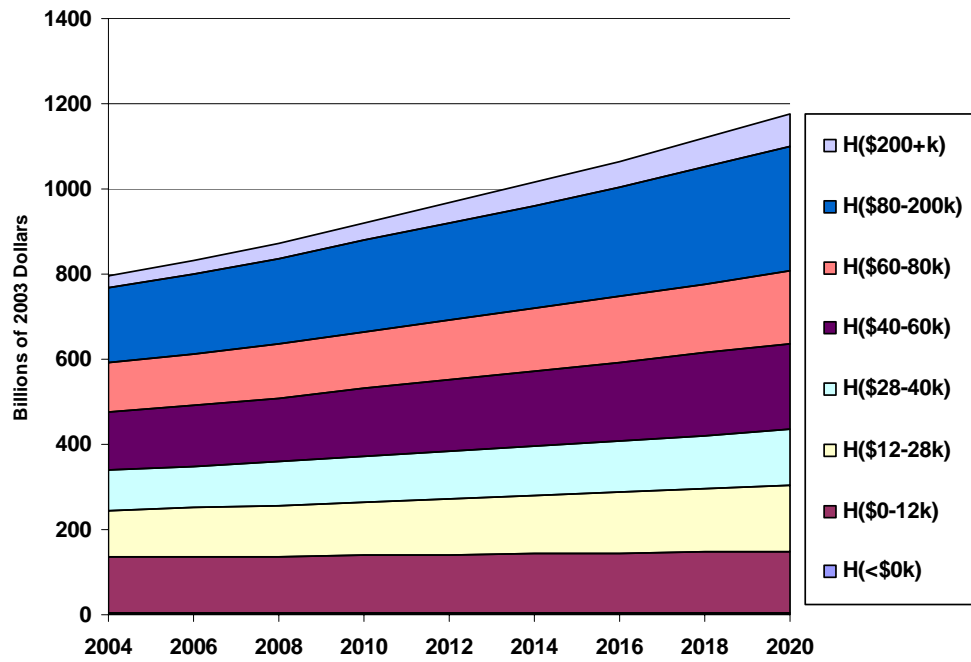


Figure 6.12: Household Consumption



7.0 Conclusions and Extensions

This report presents preliminary results from a new empirical facility for modeling the economic and environmental effects of energy and GHG-oriented policies. At the heart of this facility is a new, 2003 SAM for California and a dynamic CGE model that elucidates economy-environment linkages in California at an unprecedented level of detail. This modeling facility is currently in a prototype phase, and much estimation and formal elaboration is needed to produce more definitive analysis. However, the model is already shedding new light on leading state environmental issues, as evidenced by the eight scenarios presented above.

Generally speaking, this study's results indicate that the scope for GHG mitigation in California is considerable, and that ambitious abatement goals can probably be met without unduly adverse effects on aggregate economic growth. On the contrary, well designed GHG-reduction policies can be expansionary if they are based on appropriate incentives, limit administrative costs, and induce the innovation and adoption behavior that has delivered historical improvements in emission efficiency.

More specifically, this report presents preliminary estimates for many of the leading energy efficiency and GHG mitigation schemes currently under discussion—including Pavley, promotion of long run energy efficiency, and renewable portfolio standards. The model's preliminary results give aggregate guidance about each of these policies, indicating that Pavley has the potential for substantial and growth-friendly GHG mitigation, while the other two will have desirable but much more modest effects. Despite the lesser effects, the model revealed capacity to design and simulate more sophisticated incentive policies that can amplify gains, including inducements for technology substitution, innovation, and accelerated adoption.

Over the coming years of the project, many extensions are envisioned. These will combine to make the models empirical results more definitive and to extend the scope of analysis in many ways. Together, this capacity will deliver a new generation of research tools to improve visibility and effectiveness for state policy makers.

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9.0 Glossary

BEA	Bureau of Economic Analysis
Btu	British thermal unit
CALEB	California Energy Balance Database
CES	constant-elasticity-of-substitution
CGE	calibrated or computable general equilibrium
CGENF	General Fund
CH ₄	methane
CHP	combined heat and power
CMU-GDI	Carnegie Mellon University's Green Design Initiative
CO ₂	carbon dioxide
DOF	California Department of Finance
DRAM	Dynamic Revenue Analysis Model
EDRAM	Enhanced Dynamic Revenue Analysis Model
EELR	Energy Efficiency in the Long Run
EIA	Energy Information Administration
EIO-LCA	Economic Input-Output Life-Cycle Assessment
FSDEF	federal defense spending
FSNON	federal nondefense spending
FTB	Franchise Tax Board
FTDUT	non-sector specific excise tax
FTMSC	miscellaneous
FTPIT	personal income tax
FTPPO	corporation tax
FTSOC	Social Security
GAMS	General Algebraic Modeling System
GDP	gross domestic product
GE	general equilibrium

GHG	greenhouse gas
GSP	gross state product
HFC	hydrofluorocarbon
IMPLAN	an economic impact modeling system
IO	input-output
IRS	Internal Revenue Service
LBNL	Lawrence Berkeley National Laboratory
LTPRP	local property tax
LTSAU	local tax sales and use
LTFMS	local tax miscellaneous on firms
LTHHS	local tax miscellaneous on households
LTMSC	local miscellaneous
LSTRA	local transportation
LSCOR	local corrections
LSK14	local kindergarten through 14
LSWEL	local welfare
LSHTH	local health
LSOTH	local other
MMT	million metric tons
MT	megaton
NAFTA	North American Free Trade Agreement
NAIS	North American Industry Classification System
N ₂ O	nitrous oxide
PV	photovoltaic
RPS	renewable portfolio standard
SAM	social accounting matrix
SF ₆	sulfur hexafluoride

Appendix A

SAM Sectors

Appendix A: SAM Sectors

Table A1.1: Industrial Sectoring and Codes

NAICS	NAICS Description	Model Sector
111110	Soybean Farming	AGRIC
111120	Oilseed (except Soybean) Farming	AGRIC
111130	Dry Pea and Bean Farming	AGRIC
111140	Wheat Farming	AGRIC
111150	Corn Farming	AGRIC
111160	Rice Farming	AGRIC
111191	Oilseed and Grain Combination Farming	AGRIC
111199	All Other Grain Farming	AGRIC
111211	Potato Farming	AGRIC
111219	Other Vegetable (except Potato) and Melon Farming	AGRIC
111310	Orange Groves	AGRIC
111320	Citrus (except Orange) Groves	AGRIC
111331	Apple Orchards	AGRIC
111332	Grape Vineyards	AGRIC
111333	Strawberry Farming	AGRIC
111334	Berry (except Strawberry) Farming	AGRIC
111335	Tree Nut Farming	AGRIC
111336	Fruit and Tree Nut Combination Farming	AGRIC
111339	Other Noncitrus Fruit Farming	AGRIC
111411	Mushroom Production	AGRIC
111419	Other Food Crops Grown Under Cover	AGRIC
111421	Nursery and Tree Production	AGRIC
111422	Floriculture Production	AGRIC
111910	Tobacco Farming	AGRIC
111920	Cotton Farming	AGRIC

111930	Sugarcane Farming	AGRIC
111940	Hay Farming	AGRIC
111991	Sugar Beet Farming	AGRIC
111992	Peanut Farming	AGRIC
111998	All Other Miscellaneous Crop Farming	AGRIC
112111	Beef Cattle Ranching and Farming	AGRIC
112112	Cattle Feedlots	AGRIC
112120	Dairy Cattle and Milk Production	AGRIC
112130	Dual-Purpose Cattle Ranching and Farming	AGRIC
112210	Hog and Pig Farming	AGRIC
112310	Chicken Egg Production	AGRIC
112320	Broilers and Other Meat Type Chicken Production	AGRIC
112330	Turkey Production	AGRIC
112340	Poultry Hatcheries	AGRIC
112390	Other Poultry Production	AGRIC
112410	Sheep Farming	AGRIC
112420	Goat Farming	AGRIC
112511	Finfish Farming and Fish Hatcheries	AGRIC
112512	Shellfish Farming	AGRIC
112519	Other Animal Aquaculture	AGRIC
112910	Apiculture	AGRIC
112920	Horses and Other Equine Production	AGRIC
112930	Fur-Bearing Animal and Rabbit Production	AGRIC
112990	All Other Animal Production	AGRIC
113110	Timber Tract Operations	OTHPRI
113210	Forest Nurseries and Gathering of Forest Products	OTHPRI
113310	Logging	OTHPRI
114111	Finfish Fishing	OTHPRI

114112	Shellfish Fishing	OTHPRI
114119	Other Marine Fishing	OTHPRI
114210	Hunting and Trapping	OTHPRI
115111	Cotton Ginning	OTHPRI
115112	Soil Preparation, Planting, and Cultivating	OTHPRI
115113	Crop Harvesting, Primarily by Machine	OTHPRI
115114	Postharvest Crop Activities (except Cotton Ginning)	OTHPRI
115115	Farm Labor Contractors and Crew Leaders	OTHPRI
115116	Farm Management Services	OTHPRI
115210	Support Activities for Animal Production	OTHPRI
115310	Support Activities for Forestry	OTHPRI
211111	Crude Petroleum and Natural Gas Extraction	OILGAS
211112	Natural Gas Liquid Extraction	OILGAS
212111	Bituminous Coal and Lignite Surface Mining	OTHPRI
212112	Bituminous Coal Underground Mining	OTHPRI
212113	Anthracite Mining	OTHPRI
212210	Iron Ore Mining	OTHPRI
212221	Gold Ore Mining	OTHPRI
212222	Silver Ore Mining	OTHPRI
212231	Lead Ore and Zinc Ore Mining	OTHPRI
212234	Copper Ore and Nickel Ore Mining	OTHPRI
212291	Uranium-Radium-Vanadium Ore Mining	OTHPRI
212299	All Other Metal Ore Mining	OTHPRI
212311	Dimension Stone Mining and Quarrying	OTHPRI
212312	Crushed and Broken Limestone Mining and Quarrying	OTHPRI
212313	Crushed and Broken Granite Mining and Quarrying	OTHPRI
212319	Other Crushed and Broken Stone Mining and Quarrying	OTHPRI
212321	Construction Sand and Gravel Mining	OTHPRI

212322	Industrial Sand Mining	OTHPRI
212324	Kaolin and Ball Clay Mining	OTHPRI
212325	Clay and Ceramic and Refractory Minerals Mining	OTHPRI
212391	Potash, Soda, and Borate Mineral Mining	OTHPRI
212392	Phosphate Rock Mining	OTHPRI
212393	Other Chemical and Fertilizer Mineral Mining	OTHPRI
212399	All Other Nonmetallic Mineral Mining	OTHPRI
213111	Drilling Oil and Gas Wells	OTHPRI
213112	Support Activities for Oil and Gas Operations	OTHPRI
213113	Support Activities for Coal Mining	OTHPRI
213114	Support Activities for Metal Mining	OTHPRI
213115	Support Activities for Nonmetallic Minerals (except Fuels)	OTHPRI
221111	Hydroelectric Power Generation	DISTEL
221112	Fossil Fuel Electric Power Generation	DISTEL
221113	Nuclear Electric Power Generation	DISTEL
221119	Other Electric Power Generation	DISTEL
221121	Electric Bulk Power Transmission and Control	DISTEL
221122	Electric Power Distribution	DISTEL
221210	Natural Gas Distribution	DSTGAS
221310	Water Supply and Irrigation Systems	DSTOTH
221320	Sewage Treatment Facilities	DSTOTH
221330	Steam and Air-Conditioning Supply	DSTOTH
236115	New Single-Family Housing Construction (except Operative Builders)	CONRES
236116	New Multifamily Housing Construction (except Operative Builders)	CONRES
236117	New Housing Operative Builders	CONRES
236118	Residential Remodelers	CONRES
236210	Industrial Building Construction	CONNON
236220	Commercial and Institutional Building Construction	CONNON

237110	Water and Sewer Line and Related Structures Construction	CONUTL
237120	Oil and Gas Pipeline and Related Structures Construction	CONUTL
237130	Power and Communication Line and Related Structures Construction	CONUTL
237210	Land Subdivision	CONNON
237310	Highway, Street, and Bridge Construction	CONSTR
237990	Other Heavy and Civil Engineering Construction	CONOTH
238110	Poured Concrete Foundation and Structure Contractors	CONOTH
238111		CONOTH
238112		CONOTH
238120	Structural Steel and Precast Concrete Contractors	CONOTH
238121		CONOTH
238122		CONOTH
238130	Framing Contractors	CONOTH
238131		CONOTH
238132		CONOTH
238140	Masonry Contractors	CONOTH
238141		CONOTH
238142		CONOTH
238150	Glass and Glazing Contractors	CONOTH
238151		CONOTH
238152		CONOTH
238160	Roofing Contractors	CONOTH
238161		CONOTH
238162		CONOTH
238170	Siding Contractors	CONOTH
238171		CONOTH
238172		CONOTH
238190	Other Foundation, Structure, and Building Exterior Contractors	CONOTH

238191		CONOTH
238192		CONOTH
238200	Building Equipment Contractors	CONOTH
238210	Electrical Contractors	CONOTH
238211		CONOTH
238212		CONOTH
238220	Plumbing, Heating, and Air-Conditioning Contractors	CONOTH
238221		CONOTH
238222		CONOTH
238290	Other Building Equipment Contractors	CONOTH
238291		CONOTH
238292		CONOTH
238300	Building Finishing Contractors	CONOTH
238310	Drywall and Insulation Contractors	CONOTH
238311		CONOTH
238312		CONOTH
238320	Painting and Wall Covering Contractors	CONOTH
238321		CONOTH
238322		CONOTH
238330	Flooring Contractors	CONOTH
238331		CONOTH
238332		CONOTH
238340	Tile and Terrazzo Contractors	CONOTH
238341		CONOTH
238342		CONOTH
238350	Finish Carpentry Contractors	CONOTH
238351		CONOTH
238352		CONOTH

238390	Other Building Finishing Contractors	CONOTH
238391		CONOTH
238392		CONOTH
238900	Other Specialty Trade Contractors	CONOTH
238910	Site Preparation Contractors	CONOTH
238911		CONOTH
238912		CONOTH
238990	All Other Specialty Trade Contractors	CONOTH
238991		CONOTH
238992		CONOTH
311111	Dog and Cat Food Manufacturing	FDMFG
311119	Other Animal Food Manufacturing	FDMFG
311211	Flour Milling	FDMFG
311212	Rice Milling	FDMFG
311213	Malt Manufacturing	FDMFG
311221	Wet Corn Milling	FDMFG
311222	Soybean Processing	FDMFG
311223	Other Oilseed Processing	FDMFG
311225	Fats and Oils Refining and Blending	FDMFG
311230	Breakfast Cereal Manufacturing	FDMFG
311311	Sugarcane Mills	FDMFG
311312	Cane Sugar Refining	FDMFG
311313	Beet Sugar Manufacturing	FDMFG
311320	Chocolate and Confectionery Manufacturing from Cacao Beans	FDMFG
311330	Confectionery Manufacturing from Purchased Chocolate	FDMFG
311340	Nonchocolate Confectionery Manufacturing	FDMFG
311411	Frozen Fruit, Juice, and Vegetable Manufacturing	FDPROC
311412	Frozen Specialty Food Manufacturing	FDPROC

311421	Fruit and Vegetable Canning	FDPROC
311422	Specialty Canning	FDPROC
311423	Dried and Dehydrated Food Manufacturing	FDPROC
311511	Fluid Milk Manufacturing	FDOTH
311512	Creamery Butter Manufacturing	FDOTH
311513	Cheese Manufacturing	FDOTH
311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing	FDOTH
311520	Ice Cream and Frozen Dessert Manufacturing	FDOTH
311611	Animal (except Poultry) Slaughtering	FDOTH
311612	Meat Processed from Carcasses	FDOTH
311613	Rendering and Meat Byproduct Processing	FDOTH
311615	Poultry Processing	FDOTH
311711	Seafood Canning	FDOTH
311712	Fresh and Frozen Seafood Processing	FDOTH
311811	Retail Bakeries	FDOTH
311812	Commercial Bakeries	FDOTH
311813	Frozen Cakes, Pies, and Other Pastries Manufacturing	FDOTH
311821	Cookie and Cracker Manufacturing	FDOTH
311822	Flour Mixes and Dough Manufacturing from Purchased Flour	FDOTH
311823	Dry Pasta Manufacturing	FDOTH
311830	Tortilla Manufacturing	FDOTH
311911	Roasted Nuts and Peanut Butter Manufacturing	FDOTH
311919	Other Snack Food Manufacturing	FDOTH
311920	Coffee and Tea Manufacturing	FDOTH
311930	Flavoring Syrup and Concentrate Manufacturing	FDOTH
311941	Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing	FDOTH
311942	Spice and Extract Manufacturing	FDOTH
311991	Perishable Prepared Food Manufacturing	FDOTH

311999	All Other Miscellaneous Food Manufacturing	FDOOTH
312111	Soft Drink Manufacturing	BEVTOB
312112	Bottled Water Manufacturing	BEVTOB
312113	Ice Manufacturing	BEVTOB
312120	Breweries	BEVTOB
312130	Wineries	BEVTOB
312140	Distilleries	BEVTOB
312210	Tobacco Stemming and Redrying	BEVTOB
312221	Cigarette Manufacturing	BEVTOB
312229	Other Tobacco Product Manufacturing	BEVTOB
313111	Yarn Spinning Mills	TEXTLTH
313112	Yarn Texturizing, Throwing, and Twisting Mills	TEXTLTH
313113	Thread Mills	TEXTLTH
313210	Broadwoven Fabric Mills	TEXTLTH
313221	Narrow Fabric Mills	TEXTLTH
313222	Schiffli Machine Embroidery	TEXTLTH
313230	Nonwoven Fabric Mills	TEXTLTH
313241	Weft Knit Fabric Mills	TEXTLTH
313249	Other Knit Fabric and Lace Mills	TEXTLTH
313311	Broadwoven Fabric Finishing Mills	TEXTLTH
313312	Textile and Fabric Finishing (except Broadwoven Fabric) Mills	TEXTLTH
313320	Fabric Coating Mills	TEXTLTH
314110	Carpet and Rug Mills	TEXTLTH
314121	Curtain and Drapery Mills	TEXTLTH
314129	Other Household Textile Product Mills	TEXTLTH
314911	Textile Bag Mills	TEXTLTH
314912	Canvas and Related Product Mills	TEXTLTH
314991	Rope, Cordage, and Twine Mills	TEXTLTH

314992	Tire Cord and Tire Fabric Mills	TEXTLTH
314999	All Other Miscellaneous Textile Product Mills	TEXTLTH
315111	Sheer Hosiery Mills	APPREL
315119	Other Hosiery and Sock Mills	APPREL
315191	Outerwear Knitting Mills	APPREL
315192	Underwear and Nightwear Knitting Mills	APPREL
315211	Men's and Boys' Cut and Sew Apparel Contractors	APPREL
315212	Women's, Girls', and Infants' Cut and Sew Apparel Contractors	APPREL
315221	Men's and Boys' Cut and Sew Underwear and Nightwear Manufacturing	APPREL
315222	Men's and Boys' Cut and Sew Suit, Coat, and Overcoat Manufacturing	APPREL
315223	Men's and Boys' Cut and Sew Shirt (except Work Shirt) Manufacturing	APPREL
315224	Men's and Boys' Cut and Sew Trouser, Slack, and Jean Manufacturing	APPREL
315225	Men's and Boys' Cut and Sew Work Clothing Manufacturing	APPREL
315228	Men's and Boys' Cut and Sew Other Outerwear Manufacturing	APPREL
315231	Women's and Girls' Cut and Sew Lingerie, Loungewear, and Nightwear Manufacturing	APPREL
315232	Women's and Girls' Cut and Sew Blouse and Shirt Manufacturing	APPREL
315233	Women's and Girls' Cut and Sew Dress Manufacturing	APPREL
315234	Women's and Girls' Cut and Sew Suit, Coat, Tailored Jacket, and Skirt Manufacturing	APPREL
315239	Women's and Girls' Cut and Sew Other Outerwear Manufacturing	APPREL
315291	Infants' Cut and Sew Apparel Manufacturing	APPREL
315292	Fur and Leather Apparel Manufacturing	APPREL
315299	All Other Cut and Sew Apparel Manufacturing	APPREL
315991	Hat, Cap, and Millinery Manufacturing	APPREL
315992	Glove and Mitten Manufacturing	APPREL
315993	Men's and Boys' Neckwear Manufacturing	APPREL
315999	Other Apparel Accessories and Other Apparel Manufacturing	APPREL
316110	Leather and Hide Tanning and Finishing	TEXTLTH
316211	Rubber and Plastics Footwear Manufacturing	TEXTLTH

316212	House Slipper Manufacturing	TEXTLTH
316213	Men's Footwear (except Athletic) Manufacturing	TEXTLTH
316214	Women's Footwear (except Athletic) Manufacturing	TEXTLTH
316219	Other Footwear Manufacturing	TEXTLTH
316991	Luggage Manufacturing	TEXTLTH
316992	Women's Handbag and Purse Manufacturing	TEXTLTH
316993	Personal Leather Good (except Women's Handbag and Purse) Manufacturing	TEXTLTH
316999	All Other Leather Good Manufacturing	TEXTLTH
321113	Sawmills	WOOD
321114	Wood Preservation	WOOD
321211	Hardwood Veneer and Plywood Manufacturing	WOOD
321212	Softwood Veneer and Plywood Manufacturing	WOOD
321213	Engineered Wood Member (except Truss) Manufacturing	WOOD
321214	Truss Manufacturing	WOOD
321219	Reconstituted Wood Product Manufacturing	WOOD
321911	Wood Window and Door Manufacturing	WOOD
321912	Cut Stock, Resawing Lumber, and Planing	WOOD
321918	Other Millwork (including Flooring)	WOOD
321920	Wood Container and Pallet Manufacturing	WOOD
321991	Manufactured Home (Mobile Home) Manufacturing	WOOD
321992	Prefabricated Wood Building Manufacturing	WOOD
321999	All Other Miscellaneous Wood Product Manufacturing	WOOD
322110	Pulp Mills	PLPMLL
322121	Paper (except Newsprint) Mills	PLPMLL
322122	Newsprint Mills	PLPMLL
322130	Paperboard Mills	PLPMLL
322211	Corrugated and Solid Fiber Box Manufacturing	PAPER
322212	Folding Paperboard Box Manufacturing	PAPER

322213	Setup Paperboard Box Manufacturing	PAPER
322214	Fiber Can, Tube, Drum, and Similar Products Manufacturing	PAPER
322215	Nonfolding Sanitary Food Container Manufacturing	PAPER
322221	Coated and Laminated Packaging Paper and Plastics Film Manufacturing	PAPER
322222	Coated and Laminated Paper Manufacturing	PAPER
322223	Plastics, Foil, and Coated Paper Bag Manufacturing	PAPER
322224	Uncoated Paper and Multiwall Bag Manufacturing	PAPER
322225	Laminated Aluminum Foil Manufacturing for Flexible Packaging Uses	PAPER
322226	Surface-Coated Paperboard Manufacturing	PAPER
322231	Die-Cut Paper and Paperboard Office Supplies Manufacturing	PAPER
322232	Envelope Manufacturing	PAPER
322233	Stationery, Tablet, and Related Product Manufacturing	PAPER
322291	Sanitary Paper Product Manufacturing	PAPER
322299	All Other Converted Paper Product Manufacturing	PAPER
323110	Commercial Lithographic Printing	PRINT
323111	Commercial Gravure Printing	PRINT
323112	Commercial Flexographic Printing	PRINT
323113	Commercial Screen Printing	PRINT
323114	Quick Printing	PRINT
323115	Digital Printing	PRINT
323116	Manifold Business Forms Printing	PRINT
323117	Books Printing	PRINT
323118	Blankbook, Looseleaf Binders, and Devices Manufacturing	PRINT
323119	Other Commercial Printing	PRINT
323121	Tradebinding and Related Work	PRINT
323122	Prepress Services	PRINT
324110	Petroleum Refineries	OILREF
324121	Asphalt Paving Mixture and Block Manufacturing	OILREF

324122	Asphalt Shingle and Coating Materials Manufacturing	OILREF
324191	Petroleum Lubricating Oil and Grease Manufacturing	OILREF
324199	All Other Petroleum and Coal Products Manufacturing	OILREF
325110	Petrochemical Manufacturing	CHMBAS
325120	Industrial Gas Manufacturing	INDGAS
325131	Inorganic Dye and Pigment Manufacturing	CHMBAS
325132	Synthetic Organic Dye and Pigment Manufacturing	CHMBAS
325181	Alkalies and Chlorine Manufacturing	CHMBAS
325182	Carbon Black Manufacturing	CHMBAS
325188	All Other Basic Inorganic Chemical Manufacturing	CHMBAS
325191	Gum and Wood Chemical Manufacturing	CHMBAS
325192	Cyclic Crude and Intermediate Manufacturing	CHMBAS
325193	Ethyl Alcohol Manufacturing	CHMBAS
325199	All Other Basic Organic Chemical Manufacturing	CHMBAS
325211	Plastics Material and Resin Manufacturing	CHMBAS
325212	Synthetic Rubber Manufacturing	CHMBAS
325221	Cellulosic Organic Fiber Manufacturing	CHMBAS
325222	Noncellulosic Organic Fiber Manufacturing	CHMBAS
325311	Nitrogenous Fertilizer Manufacturing	CHMBAS
325312	Phosphatic Fertilizer Manufacturing	CHMBAS
325314	Fertilizer (Mixing Only) Manufacturing	CHMBAS
325320	Pesticide and Other Agricultural Chemical Manufacturing	CHMBAS
325411	Medicinal and Botanical Manufacturing	CHMDRG
325412	Pharmaceutical Preparation Manufacturing	CHMDRG
325413	In-Vitro Diagnostic Substance Manufacturing	CHMDRG
325414	Biological Product (except Diagnostic) Manufacturing	CHMDRG
325510	Paint and Coating Manufacturing	CHMOTH
325520	Adhesive Manufacturing	CHMOTH

325611	Soap and Other Detergent Manufacturing	CHMSPS
325612	Polish and Other Sanitation Good Manufacturing	CHMSPS
325613	Surface Active Agent Manufacturing	CHMSPS
325620	Toilet Preparation Manufacturing	CHMSPS
325910	Printing Ink Manufacturing	CHMOTH
325920	Explosives Manufacturing	CHMOTH
325991	Custom Compounding of Purchased Resins	CHMOTH
325992	Photographic Film, Paper, Plate, and Chemical Manufacturing	CHMOTH
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	CHMOTH
326111	Plastics Bag Manufacturing	PLASTC
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing	PLASTC
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	PLASTC
326121	Unlaminated Plastics Profile Shape Manufacturing	PLASTC
326122	Plastics Pipe and Pipe Fitting Manufacturing	PLASTC
326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing	PLASTC
326140	Polystyrene Foam Product Manufacturing	PLASTC
326150	Urethane and Other Foam Product (except Polystyrene) Manufacturing	PLASTC
326160	Plastics Bottle Manufacturing	PLASTC
326191	Plastics Plumbing Fixture Manufacturing	PLASTC
326192	Resilient Floor Covering Manufacturing	PLASTC
326199	All Other Plastics Product Manufacturing	PLASTC
326211	Tire Manufacturing (except Retreading)	PLASTC
326212	Tire Retreading	PLASTC
326220	Rubber and Plastics Hoses and Belting Manufacturing	PLASTC
326291	Rubber Product Manufacturing for Mechanical Use	PLASTC
326299	All Other Rubber Product Manufacturing	PLASTC
327111	Vitreous China Plumbing Fixture and China and Earthenware Bathroom Accessories Manufacturing	SCAOTH
327112	Vitreous China, Fine Earthenware, and Other Pottery Product Manufacturing	SCAOTH

327113	Porcelain Electrical Supply Manufacturing	SCAOTH
327121	Brick and Structural Clay Tile Manufacturing	SCAOTH
327122	Ceramic Wall and Floor Tile Manufacturing	SCAOTH
327123	Other Structural Clay Product Manufacturing	SCAOTH
327124	Clay Refractory Manufacturing	SCAOTH
327125	Nonclay Refractory Manufacturing	SCAOTH
327211	Flat Glass Manufacturing	GLASS
327212	Other Pressed and Blown Glass and Glassware Manufacturing	GLASS
327213	Glass Container Manufacturing	GLASS
327215	Glass Product Manufacturing Made of Purchased Glass	GLASS
327310	Cement Manufacturing	CEMENT
327320	Ready-Mix Concrete Manufacturing	CONCRT
327331	Concrete Block and Brick Manufacturing	CONCRT
327332	Concrete Pipe Manufacturing	CONCRT
327390	Other Concrete Product Manufacturing	CONCRT
327410	Lime Manufacturing	SCAOTH
327420	Gypsum Product Manufacturing	SCAOTH
327910	Abrasive Product Manufacturing	SCAOTH
327991	Cut Stone and Stone Product Manufacturing	SCAOTH
327992	Ground or Treated Mineral and Earth Manufacturing	SCAOTH
327993	Mineral Wool Manufacturing	SCAOTH
327999	All Other Miscellaneous Nonmetallic Mineral Product Manufacturing	SCAOTH
331111	Iron and Steel Mills	PRIMTL
331112	Electrometallurgical Ferroalloy Product Manufacturing	PRIMTL
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	PRIMTL
331221	Rolled Steel Shape Manufacturing	PRIMTL
331222	Steel Wire Drawing	PRIMTL
331311	Alumina Refining	PRIMTL

331312	Primary Aluminum Production	PRIMTL
331314	Secondary Smelting and Alloying of Aluminum	PRIMTL
331315	Aluminum Sheet, Plate, and Foil Manufacturing	PRIMTL
331316	Aluminum Extruded Product Manufacturing	PRIMTL
331319	Other Aluminum Rolling and Drawing	PRIMTL
331411	Primary Smelting and Refining of Copper	PRIMTL
331419	Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)	PRIMTL
331421	Copper Rolling, Drawing, and Extruding	PRIMTL
331422	Copper Wire (except Mechanical) Drawing	PRIMTL
331423	Secondary Smelting, Refining, and Alloying of Copper	PRIMTL
331491	Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	PRIMTL
331492	Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	PRIMTL
331511	Iron Foundries	PRIMTL
331512	Steel Investment Foundries	PRIMTL
331513	Steel Foundries (except Investment)	PRIMTL
331521	Aluminum Die-Casting Foundries	PRIMTL
331522	Nonferrous (except Aluminum) Die-Casting Foundries	PRIMTL
331524	Aluminum Foundries (except Die-Casting)	PRIMTL
331525	Copper Foundries (except Die-Casting)	PRIMTL
331528	Other Nonferrous Foundries (except Die-Casting)	PRIMTL
332111	Iron and Steel Forging	MTLFAB
332112	Nonferrous Forging	MTLFAB
332114	Custom Roll Forming	MTLFAB
332115	Crown and Closure Manufacturing	MTLFAB
332116	Metal Stamping	MTLFAB
332117	Powder Metallurgy Part Manufacturing	MTLFAB
332211	Cutlery and Flatware (except Precious) Manufacturing	MTLFAB
332212	Hand and Edge Tool Manufacturing	MTLFAB

332213	Saw Blade and Handsaw Manufacturing	MTLFAB
332214	Kitchen Utensil, Pot, and Pan Manufacturing	MTLFAB
332311	Prefabricated Metal Building and Component Manufacturing	MTLFAB
332312	Fabricated Structural Metal Manufacturing	MTLFAB
332313	Plate Work Manufacturing	MTLFAB
332321	Metal Window and Door Manufacturing	MTLFAB
332322	Sheet Metal Work Manufacturing	MTLFAB
332323	Ornamental and Architectural Metal Work Manufacturing	MTLFAB
332410	Power Boiler and Heat Exchanger Manufacturing	MTLFAB
332420	Metal Tank (Heavy Gauge) Manufacturing	MTLFAB
332431	Metal Can Manufacturing	MTLFAB
332439	Other Metal Container Manufacturing	MTLFAB
332510	Hardware Manufacturing	MTLFAB
332611	Spring (Heavy Gauge) Manufacturing	MTLFAB
332612	Spring (Light Gauge) Manufacturing	MTLFAB
332618	Other Fabricated Wire Product Manufacturing	MTLFAB
332710	Machine Shops	MTLFAB
332721	Precision Turned Product Manufacturing	MTLFAB
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	MTLFAB
332811	Metal Heat Treating	MTLFAB
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	MTLFAB
332813	Electroplating, Plating, Polishing, Anodizing, and Coloring	MTLFAB
332911	Industrial Valve Manufacturing	MTLFAB
332912	Fluid Power Valve and Hose Fitting Manufacturing	MTLFAB
332913	Plumbing Fixture Fitting and Trim Manufacturing	MTLFAB
332919	Other Metal Valve and Pipe Fitting Manufacturing	MTLFAB
332991	Ball and Roller Bearing Manufacturing	MTLFAB
332992	Small Arms Ammunition Manufacturing	MTLFAB

332993	Ammunition (except Small Arms) Manufacturing	MTLFAB
332994	Small Arms Manufacturing	MTLFAB
332995	Other Ordnance and Accessories Manufacturing	MTLFAB
332996	Fabricated Pipe and Pipe Fitting Manufacturing	MTLFAB
332997	Industrial Pattern Manufacturing	MTLFAB
332998	Enameled Iron and Metal Sanitary Ware Manufacturing	MTLFAB
332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	MTLFAB
333111	Farm Machinery and Equipment Manufacturing	MACHIN
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	MACHIN
333120	Construction Machinery Manufacturing	MACHIN
333131	Mining Machinery and Equipment Manufacturing	MACHIN
333132	Oil and Gas Field Machinery and Equipment Manufacturing	MACHIN
333210	Sawmill and Woodworking Machinery Manufacturing	MACHIN
333220	Plastics and Rubber Industry Machinery Manufacturing	MACHIN
333291	Paper Industry Machinery Manufacturing	MACHIN
333292	Textile Machinery Manufacturing	MACHIN
333293	Printing Machinery and Equipment Manufacturing	MACHIN
333294	Food Product Machinery Manufacturing	MACHIN
333295	Semiconductor Machinery Manufacturing	MACHIN
333298	All Other Industrial Machinery Manufacturing	MACHIN
333311	Automatic Vending Machine Manufacturing	MACHIN
333312	Commercial Laundry, Drycleaning, and Pressing Machine Manufacturing	MACHIN
333313	Office Machinery Manufacturing	MACHIN
333314	Optical Instrument and Lens Manufacturing	MACHIN
333315	Photographic and Photocopying Equipment Manufacturing	MACHIN
333319	Other Commercial and Service Industry Machinery Manufacturing	MACHIN
333411	Air Purification Equipment Manufacturing	MACHIN
333412	Industrial and Commercial Fan and Blower Manufacturing	MACHIN

333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	MACHIN
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	MACHIN
333511	Industrial Mold Manufacturing	MACHIN
333512	Machine Tool (Metal Cutting Types) Manufacturing	MACHIN
333513	Machine Tool (Metal Forming Types) Manufacturing	MACHIN
333514	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	MACHIN
333515	Cutting Tool and Machine Tool Accessory Manufacturing	MACHIN
333516	Rolling Mill Machinery and Equipment Manufacturing	MACHIN
333518	Other Metalworking Machinery Manufacturing	MACHIN
333611	Turbine and Turbine Generator Set Units Manufacturing	MACHIN
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	MACHIN
333613	Mechanical Power Transmission Equipment Manufacturing	MACHIN
333618	Other Engine Equipment Manufacturing	MACHIN
333911	Pump and Pumping Equipment Manufacturing	MACHIN
333912	Air and Gas Compressor Manufacturing	MACHIN
333913	Measuring and Dispensing Pump Manufacturing	MACHIN
333921	Elevator and Moving Stairway Manufacturing	MACHIN
333922	Conveyor and Conveying Equipment Manufacturing	MACHIN
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	MACHIN
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	MACHIN
333991	Power-Driven Handtool Manufacturing	MACHIN
333992	Welding and Soldering Equipment Manufacturing	MACHIN
333993	Packaging Machinery Manufacturing	MACHIN
333994	Industrial Process Furnace and Oven Manufacturing	MACHIN
333995	Fluid Power Cylinder and Actuator Manufacturing	MACHIN
333996	Fluid Power Pump and Motor Manufacturing	MACHIN
333997	Scale and Balance (except Laboratory) Manufacturing	MACHIN
333999	All Other Miscellaneous General Purpose Machinery Manufacturing	MACHIN

334111	Electronic Computer Manufacturing	CMPMFG
334112	Computer Storage Device Manufacturing	CMPMFG
334113	Computer Terminal Manufacturing	CMPMFG
334119	Other Computer Peripheral Equipment Manufacturing	CMPMFG
334210	Telephone Apparatus Manufacturing	CMPCMM
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	CMPCMM
334290	Other Communications Equipment Manufacturing	CMPCMM
334310	Audio and Video Equipment Manufacturing	CMPRTS
334411	Electron Tube Manufacturing	CMPRTS
334412	Bare Printed Circuit Board Manufacturing	CMPRTS
334413	Semiconductor and Related Device Manufacturing	CMPRTS
334414	Electronic Capacitor Manufacturing	CMPRTS
334415	Electronic Resistor Manufacturing	CMPRTS
334416	Electronic Coil, Transformer, and Other Inductor Manufacturing	CMPRTS
334417	Electronic Connector Manufacturing	CMPRTS
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	CMPRTS
334419	Other Electronic Component Manufacturing	CMPRTS
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	CMPINS
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	CMPINS
334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	CMPINS
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	CMPINS
334514	Totalizing Fluid Meter and Counting Device Manufacturing	CMPINS
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	CMPINS
334516	Analytical Laboratory Instrument Manufacturing	CMPINS
334517	Irradiation Apparatus Manufacturing	CMPINS
334518	Watch, Clock, and Part Manufacturing	CMPINS

334519	Other Measuring and Controlling Device Manufacturing	CMPINS
334611	Software Reproducing	CMPMED
334612	Prerecorded Compact Disc (except Software), Tape, and Record Reproducing	CMPMED
334613	Magnetic and Optical Recording Media Manufacturing	CMPMED
335110	Electric Lamp Bulb and Part Manufacturing	ELCTRC
335121	Residential Electric Lighting Fixture Manufacturing	ELCTRC
335122	Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing	ELCTRC
335129	Other Lighting Equipment Manufacturing	ELCTRC
335211	Electric Housewares and Household Fan Manufacturing	ELCTRC
335212	Household Vacuum Cleaner Manufacturing	ELCTRC
335221	Household Cooking Appliance Manufacturing	ELCTRC
335222	Household Refrigerator and Home Freezer Manufacturing	ELCTRC
335224	Household Laundry Equipment Manufacturing	ELCTRC
335228	Other Major Household Appliance Manufacturing	ELCTRC
335311	Power, Distribution, and Specialty Transformer Manufacturing	ELCTRC
335312	Motor and Generator Manufacturing	ELCTRC
335313	Switchgear and Switchboard Apparatus Manufacturing	ELCTRC
335314	Relay and Industrial Control Manufacturing	ELCTRC
335911	Storage Battery Manufacturing	ELCTRC
335912	Primary Battery Manufacturing	ELCTRC
335921	Fiber Optic Cable Manufacturing	ELCTRC
335929	Other Communication and Energy Wire Manufacturing	ELCTRC
335931	Current-Carrying Wiring Device Manufacturing	ELCTRC
335932	Noncurrent-Carrying Wiring Device Manufacturing	ELCTRC
335991	Carbon and Graphite Product Manufacturing	ELCTRC
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	ELCTRC
336111	Automobile Manufacturing	AUTOMF
336112	Light Truck and Utility Vehicle Manufacturing	AUTOMF

336120	Heavy Duty Truck Manufacturing	VEHMFG
336211	Motor Vehicle Body Manufacturing	VEHBDY
336212	Truck Trailer Manufacturing	VEHMFG
336213	Motor Home Manufacturing	VEHMFG
336214	Travel Trailer and Camper Manufacturing	VEHMFG
336311	Carburetor, Piston, Piston Ring, and Valve Manufacturing	VEHPRT
336312	Gasoline Engine and Engine Parts Manufacturing	VEHPRT
336321	Vehicular Lighting Equipment Manufacturing	VEHPRT
336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing	VEHPRT
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	VEHPRT
336340	Motor Vehicle Brake System Manufacturing	VEHPRT
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing	VEHPRT
336360	Motor Vehicle Seating and Interior Trim Manufacturing	VEHPRT
336370	Motor Vehicle Metal Stamping	VEHPRT
336391	Motor Vehicle Air-Conditioning Manufacturing	VEHPRT
336399	All Other Motor Vehicle Parts Manufacturing	VEHPRT
336411	Aircraft Manufacturing	VEHAER
336412	Aircraft Engine and Engine Parts Manufacturing	VEHAER
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	VEHAER
336414	Guided Missile and Space Vehicle Manufacturing	VEHAER
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	VEHAER
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	VEHAER
336510	Railroad Rolling Stock Manufacturing	VEHOTH
336611	Ship Building and Repairing	VEHSHP
336612	Boat Building	VEHSHP
336991	Motorcycle, Bicycle, and Parts Manufacturing	VEHOTH
336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing	VEHOTH

336999	All Other Transportation Equipment Manufacturing	VEHOTH
337110	Wood Kitchen Cabinet and Countertop Manufacturing	FURN
337121	Upholstered Household Furniture Manufacturing	FURN
337122	Nonupholstered Wood Household Furniture Manufacturing	FURN
337124	Metal Household Furniture Manufacturing	FURN
337125	Household Furniture (except Wood and Metal) Manufacturing	FURN
337127	Institutional Furniture Manufacturing	FURN
337129	Wood Television, Radio, and Sewing Machine Cabinet Manufacturing	FURN
337211	Wood Office Furniture Manufacturing	FURN
337212	Custom Architectural Woodwork and Millwork Manufacturing	FURN
337214	Office Furniture (except Wood) Manufacturing	FURN
337215	Showcase, Partition, Shelving, and Locker Manufacturing	FURN
337910	Mattress Manufacturing	FURN
337920	Blind and Shade Manufacturing	FURN
339111	Laboratory Apparatus and Furniture Manufacturing	LABDNT
339112	Surgical and Medical Instrument Manufacturing	LABDNT
339113	Surgical Appliance and Supplies Manufacturing	LABDNT
339114	Dental Equipment and Supplies Manufacturing	LABDNT
339115	Ophthalmic Goods Manufacturing	LABDNT
339116	Dental Laboratories	LABDNT
339911	Jewelry (except Costume) Manufacturing	MSCMFG
339912	Silverware and Hollowware Manufacturing	MSCMFG
339913	Jewelers' Material and Lapidary Work Manufacturing	MSCMFG
339914	Costume Jewelry and Novelty Manufacturing	MSCMFG
339920	Sporting and Athletic Goods Manufacturing	MSCMFG
339931	Doll and Stuffed Toy Manufacturing	MSCMFG
339932	Game, Toy, and Children's Vehicle Manufacturing	MSCMFG
339941	Pen and Mechanical Pencil Manufacturing	MSCMFG

339942	Lead Pencil and Art Good Manufacturing	MSCMFG
339943	Marking Device Manufacturing	MSCMFG
339944	Carbon Paper and Inked Ribbon Manufacturing	MSCMFG
339950	Sign Manufacturing	MSCMFG
339991	Gasket, Packing, and Sealing Device Manufacturing	MSCMFG
339992	Musical Instrument Manufacturing	MSCMFG
339993	Fastener, Button, Needle, and Pin Manufacturing	MSCMFG
339994	Broom, Brush, and Mop Manufacturing	MSCMFG
339995	Burial Casket Manufacturing	MSCMFG
339999	All Other Miscellaneous Manufacturing	MSCMFG
423110	Automobile and Other Motor Vehicle Merchant Wholesalers	WHLDUR
423120	Motor Vehicle Supplies and New Parts Merchant Wholesalers	WHLDUR
423130	Tire and Tube Merchant Wholesalers	WHLDUR
423140	Motor Vehicle Parts (Used) Merchant Wholesalers	WHLDUR
423210	Furniture Merchant Wholesalers	WHLDUR
423220	Home Furnishing Merchant Wholesalers	WHLDUR
423310	Lumber, Plywood, Millwork, and Wood Panel Merchant Wholesalers	WHLDUR
423320	Brick, Stone, and Related Construction Material Merchant Wholesalers	WHLDUR
423330	Roofing, Siding, and Insulation Material Merchant Wholesalers	WHLDUR
423390	Other Construction Material Merchant Wholesalers	WHLDUR
423410	Photographic Equipment and Supplies Merchant Wholesalers	WHLDUR
423420	Office Equipment Merchant Wholesalers	WHLDUR
423430	Computer and Computer Peripheral Equipment and Software Merchant Wholesalers	WHLDUR
423440	Other Commercial Equipment Merchant Wholesalers	WHLDUR
423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers	WHLDUR
423460	Ophthalmic Goods Merchant Wholesalers	WHLDUR
423490	Other Professional Equipment and Supplies Merchant Wholesalers	WHLDUR
423510	Metal Service Centers and Other Metal Merchant Wholesalers	WHLDUR

423520	Coal and Other Mineral and Ore Merchant Wholesalers	WHLDUR
423610	Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers	WHLDUR
423620	Electrical and Electronic Appliance, Television, and Radio Set Merchant Wholesalers	WHLDUR
423690	Other Electronic Parts and Equipment Merchant Wholesalers	WHLDUR
423710	Hardware Merchant Wholesalers	WHLDUR
423720	Plumbing and Heating Equipment and Supplies (Hydronics) Merchant Wholesalers	WHLDUR
423730	Warm Air Heating and Air-Conditioning Equipment and Supplies Merchant Wholesalers	WHLDUR
423740	Refrigeration Equipment and Supplies Merchant Wholesalers	WHLDUR
423810	Construction and Mining (except Oil Well) Machinery and Equipment Merchant Wholesalers	WHLDUR
423820	Farm and Garden Machinery and Equipment Merchant Wholesalers	WHLDUR
423830	Industrial Machinery and Equipment Merchant Wholesalers	WHLDUR
423840	Industrial Supplies Merchant Wholesalers	WHLDUR
423850	Service Establishment Equipment and Supplies Merchant Wholesalers	WHLDUR
423860	Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	WHLDUR
423910	Sporting and Recreational Goods and Supplies Merchant Wholesalers	WHLDUR
423920	Toy and Hobby Goods and Supplies Merchant Wholesalers	WHLDUR
423930	Recyclable Material Merchant Wholesalers	WHLDUR
423940	Jewelry, Watch, Precious Stone, and Precious Metal Merchant Wholesalers	WHLDUR
423990	Other Miscellaneous Durable Goods Merchant Wholesalers	WHLDUR
424110	Printing and Writing Paper Merchant Wholesalers	WHLNON
424120	Stationery and Office Supplies Merchant Wholesalers	WHLNON
424130	Industrial and Personal Service Paper Merchant Wholesalers	WHLNON
424210	Drugs and Druggists' Sundries Merchant Wholesalers	WHLNON
424310	Piece Goods, Notions, and Other Dry Goods Merchant Wholesalers	WHLNON
424320	Men's and Boys' Clothing and Furnishings Merchant Wholesalers	WHLNON
424330	Women's, Children's, and Infants' Clothing and Accessories Merchant Wholesalers	WHLNON

424340	Footwear Merchant Wholesalers	WHLNON
424410	General Line Grocery Merchant Wholesalers	WHLNON
424420	Packaged Frozen Food Merchant Wholesalers	WHLNON
424430	Dairy Product (except Dried or Canned) Merchant Wholesalers	WHLNON
424440	Poultry and Poultry Product Merchant Wholesalers	WHLNON
424450	Confectionery Merchant Wholesalers	WHLNON
424460	Fish and Seafood Merchant Wholesalers	WHLNON
424470	Meat and Meat Product Merchant Wholesalers	WHLNON
424480	Fresh Fruit and Vegetable Merchant Wholesalers	WHLNON
424490	Other Grocery and Related Products Merchant Wholesalers	WHLNON
424510	Grain and Field Bean Merchant Wholesalers	WHLNON
424520	Livestock Merchant Wholesalers	WHLNON
424590	Other Farm Product Raw Material Merchant Wholesalers	WHLNON
424610	Plastics Materials and Basic Forms and Shapes Merchant Wholesalers	WHLNON
424690	Other Chemical and Allied Products Merchant Wholesalers	WHLNON
424710	Petroleum Bulk Stations and Terminals	WHLNON
424720	Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)	WHLNON
424810	Beer and Ale Merchant Wholesalers	WHLNON
424820	Wine and Distilled Alcoholic Beverage Merchant Wholesalers	WHLNON
424910	Farm Supplies Merchant Wholesalers	WHLNON
424920	Book, Periodical, and Newspaper Merchant Wholesalers	WHLNON
424930	Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers	WHLNON
424940	Tobacco and Tobacco Product Merchant Wholesalers	WHLNON
424950	Paint, Varnish, and Supplies Merchant Wholesalers	WHLNON
424990	Other Miscellaneous Nondurable Goods Merchant Wholesalers	WHLNON
425110	Business to Business Electronic Markets	WHLAGN
425120	Wholesale Trade Agents and Brokers	WHLAGN
441110	New Car Dealers	RETAIL

441120	Used Car Dealers	RETAIL
441210	Recreational Vehicle Dealers	RETAIL
441221	Motorcycle Dealers	RETAIL
441222	Boat Dealers	RETAIL
441229	All Other Motor Vehicle Dealers	RETAIL
441310	Automotive Parts and Accessories Stores	RETAIL
441320	Tire Dealers	RETAIL
442110	Furniture Stores	RETAIL
442210	Floor Covering Stores	RETAIL
442291	Window Treatment Stores	RETAIL
442299	All Other Home Furnishings Stores	RETAIL
443111	Household Appliance Stores	RETAIL
443112	Radio, Television, and Other Electronics Stores	RETAIL
443120	Computer and Software Stores	RETAIL
443130	Camera and Photographic Supplies Stores	RETAIL
444110	Home Centers	RETAIL
444120	Paint and Wallpaper Stores	RETAIL
444130	Hardware Stores	RETAIL
444190	Other Building Material Dealers	RETAIL
444210	Outdoor Power Equipment Stores	RETAIL
444220	Nursery, Garden Center, and Farm Supply Stores	RETAIL
445110	Supermarkets and Other Grocery (except Convenience) Stores	RETAIL
445120	Convenience Stores	RETAIL
445210	Meat Markets	RETAIL
445220	Fish and Seafood Markets	RETAIL
445230	Fruit and Vegetable Markets	RETAIL
445291	Baked Goods Stores	RETAIL
445292	Confectionery and Nut Stores	RETAIL

445299	All Other Specialty Food Stores	RETAIL
445310	Beer, Wine, and Liquor Stores	RETAIL
446110	Pharmacies and Drug Stores	RETAIL
446120	Cosmetics, Beauty Supplies, and Perfume Stores	RETAIL
446130	Optical Goods Stores	RETAIL
446191	Food (Health) Supplement Stores	RETAIL
446199	All Other Health and Personal Care Stores	RETAIL
447110	Gasoline Stations with Convenience Stores	RETAIL
447190	Other Gasoline Stations	RETAIL
448110	Men's Clothing Stores	RETAIL
448120	Women's Clothing Stores	RETAIL
448130	Children's and Infants' Clothing Stores	RETAIL
448140	Family Clothing Stores	RETAIL
448150	Clothing Accessories Stores	RETAIL
448190	Other Clothing Stores	RETAIL
448210	Shoe Stores	RETAIL
448310	Jewelry Stores	RETAIL
448320	Luggage and Leather Goods Stores	RETAIL
451110	Sporting Goods Stores	RETAIL
451120	Hobby, Toy, and Game Stores	RETAIL
451130	Sewing, Needlework, and Piece Goods Stores	RETAIL
451140	Musical Instrument and Supplies Stores	RETAIL
451211	Book Stores	RETAIL
451212	News Dealers and Newsstands	RETAIL
451220	Prerecorded Tape, Compact Disc, and Record Stores	RETAIL
452111	Department Stores (except Discount Department Stores)	RETAIL
452112	Discount Department Stores	RETAIL
452910	Warehouse Clubs and Supercenters	RETAIL

452990	All Other General Merchandise Stores	RETAIL
453110	Florists	RETAIL
453210	Office Supplies and Stationery Stores	RETAIL
453220	Gift, Novelty, and Souvenir Stores	RETAIL
453310	Used Merchandise Stores	RETAIL
453910	Pet and Pet Supplies Stores	RETAIL
453920	Art Dealers	RETAIL
453930	Manufactured (Mobile) Home Dealers	RETAIL
453991	Tobacco Stores	RETAIL
453998	All Other Miscellaneous Store Retailers (except Tobacco Stores)	RETAIL
454111	Electronic Shopping	RETAIL
454112	Electronic Auctions	RETAIL
454113	Mail-Order Houses	RETAIL
454210	Vending Machine Operators	RETAIL
454311	Heating Oil Dealers	RETAIL
454312	Liquefied Petroleum Gas (Bottled Gas) Dealers	RETAIL
454319	Other Fuel Dealers	RETAIL
454390	Other Direct Selling Establishments	RETAIL
481111	Scheduled Passenger Air Transportation	TRANSP
481112	Scheduled Freight Air Transportation	TRANSP
481211	Nonscheduled Chartered Passenger Air Transportation	TRANSP
481212	Nonscheduled Chartered Freight Air Transportation	TRANSP
481219	Other Nonscheduled Air Transportation	TRANSP
482111	Line-Haul Railroads	TRANSP
482112	Short Line Railroads	TRANSP
483111	Deep Sea Freight Transportation	TRANSP
483112	Deep Sea Passenger Transportation	TRANSP
483113	Coastal and Great Lakes Freight Transportation	TRANSP

483114	Coastal and Great Lakes Passenger Transportation	TRANSP
483211	Inland Water Freight Transportation	TRANSP
483212	Inland Water Passenger Transportation	TRANSP
484110	General Freight Trucking, Local	TRANSP
484121	General Freight Trucking, Long-Distance, Truckload	TRANSP
484122	General Freight Trucking, Long-Distance, Less Than Truckload	TRANSP
484210	Used Household and Office Goods Moving	TRANSP
484220	Specialized Freight (except Used Goods) Trucking, Local	TRANSP
484230	Specialized Freight (except Used Goods) Trucking, Long-Distance	TRANSP
485111	Mixed Mode Transit Systems	TRANSP
485112	Commuter Rail Systems	TRANSP
485113	Bus and Other Motor Vehicle Transit Systems	TRANSP
485119	Other Urban Transit Systems	TRANSP
485210	Interurban and Rural Bus Transportation	TRANSP
485310	Taxi Service	TRANSP
485320	Limousine Service	TRANSP
485410	School and Employee Bus Transportation	TRANSP
485510	Charter Bus Industry	TRANSP
485991	Special Needs Transportation	TRANSP
485999	All Other Transit and Ground Passenger Transportation	TRANSP
486110	Pipeline Transportation of Crude Oil	TRANSP
486210	Pipeline Transportation of Natural Gas	TRANSP
486910	Pipeline Transportation of Refined Petroleum Products	TRANSP
486990	All Other Pipeline Transportation	TRANSP
487110	Scenic and Sightseeing Transportation, Land	TRANSP
487210	Scenic and Sightseeing Transportation, Water	TRANSP
487990	Scenic and Sightseeing Transportation, Other	TRANSP
488111	Air Traffic Control	TRANSP

488119	Other Airport Operations	TRANSP
488190	Other Support Activities for Air Transportation	TRANSP
488210	Support Activities for Rail Transportation	TRANSP
488310	Port and Harbor Operations	TRANSP
488320	Marine Cargo Handling	TRANSP
488330	Navigational Services to Shipping	TRANSP
488390	Other Support Activities for Water Transportation	TRANSP
488410	Motor Vehicle Towing	TRANSP
488490	Other Support Activities for Road Transportation	TRANSP
488510	Freight Transportation Arrangement	TRANSP
488991	Packing and Crating	TRANSP
488999	All Other Support Activities for Transportation	TRANSP
491110	Postal Service	TRANSP
492110	Couriers	TRANSP
492210	Local Messengers and Local Delivery	TRANSP
493110	General Warehousing and Storage	TRANSP
493120	Refrigerated Warehousing and Storage	TRANSP
493130	Farm Product Warehousing and Storage	TRANSP
493190	Other Warehousing and Storage	TRANSP
511110	Newspaper Publishers	PRINT
511120	Periodical Publishers	PRINT
511130	Book Publishers	PRINT
511140	Directory and Mailing List Publishers	PRINT
511191	Greeting Card Publishers	PRINT
511199	All Other Publishers	PRINT
511210	Software Publishers	PRINT
512110	Motion Picture and Video Production	INFOPC
512120	Motion Picture and Video Distribution	INFOPC

512131	Motion Picture Theaters (except Drive-Ins)	INFOPC
512132	Drive-In Motion Picture Theaters	INFOPC
512191	Teleproduction and Other Postproduction Services	INFOPC
512199	Other Motion Picture and Video Industries	INFOPC
512210	Record Production	INFOTH
512220	Integrated Record Production/Distribution	INFOTH
512230	Music Publishers	INFOTH
512240	Sound Recording Studios	INFOTH
512290	Other Sound Recording Industries	INFOTH
515111	Radio Networks	INFOTH
515112	Radio Stations	INFOTH
515120	Television Broadcasting	INFOTH
515210	Cable and Other Subscription Programming	INFOTH
516110	Internet Publishing and Broadcasting	INFOTH
517110	Wired Telecommunications Carriers	INFOTL
517211	Paging	INFOTL
517212	Cellular and Other Wireless Telecommunications	INFOTL
517310	Telecommunications Resellers	INFOTL
517410	Satellite Telecommunications	INFOTL
517510	Cable and Other Program Distribution	INFOTL
517910	Other Telecommunications	INFOTL
518111	Internet Service Providers	INFCOM
518112	Web Search Portals	INFCOM
518210	Data Processing, Hosting, and Related Services	INFCOM
519110	News Syndicates	INFCOM
519120	Libraries and Archives	INFCOM
519190	All Other Information Services	INFCOM
521110	Monetary Authorities - Central Bank	FIBNKS

522110	Commercial Banking	FIBNKS
522120	Savings Institutions	FIBNKS
522130	Credit Unions	FIBNKS
522190	Other Depository Credit Intermediation	FIBNKS
522210	Credit Card Issuing	FIBNKS
522220	Sales Financing	FIBNKS
522291	Consumer Lending	FIBNKS
522292	Real Estate Credit	FIBNKS
522293	International Trade Financing	FIBNKS
522294	Secondary Market Financing	FIBNKS
522298	All Other Nondepository Credit Intermediation	FIBNKS
522310	Mortgage and Nonmortgage Loan Brokers	FIBNKS
522320	Financial Transactions Processing, Reserve, and Clearinghouse Activities	FIBNKS
522390	Other Activities Related to Credit Intermediation	FIBNKS
523110	Investment Banking and Securities Dealing	FINSEC
523120	Securities Brokerage	FINSEC
523130	Commodity Contracts Dealing	FINSEC
523140	Commodity Contracts Brokerage	FINSEC
523210	Securities and Commodity Exchanges	FINSEC
523910	Miscellaneous Intermediation	FINSEC
523920	Portfolio Management	FINSEC
523930	Investment Advice	FINSEC
523991	Trust, Fiduciary, and Custody Activities	FINSEC
523999	Miscellaneous Financial Investment Activities	FINSEC
524113	Direct Life Insurance Carriers	FINSUR
524114	Direct Health and Medical Insurance Carriers	FINSUR
524126	Direct Property and Casualty Insurance Carriers	FINSUR
524127	Direct Title Insurance Carriers	FINSUR

524128	Other Direct Insurance (except Life, Health, and Medical) Carriers	FINSUR
524130	Reinsurance Carriers	FINSUR
524210	Insurance Agencies and Brokerages	FINSUR
524291	Claims Adjusting	FINSUR
524292	Third Party Administration of Insurance and Pension Funds	FINSUR
524298	All Other Insurance Related Activities	FINSUR
525110	Pension Funds	FINOTH
525120	Health and Welfare Funds	FINOTH
525190	Other Insurance Funds	FINOTH
525910	Open-End Investment Funds	FINOTH
525920	Trusts, Estates, and Agency Accounts	FINOTH
525930	Real Estate Investment Trusts	FINOTH
525990	Other Financial Vehicles	FINOTH
531110	Lessors of Residential Buildings and Dwellings	FIREAL
531120	Lessors of Nonresidential Buildings (except Miniwarehouses)	FIREAL
531130	Lessors of Miniwarehouses and Self-Storage Units	FIREAL
531190	Lessors of Other Real Estate Property	FIREAL
531210	Offices of Real Estate Agents and Brokers	FIREAL
531311	Residential Property Managers	FIREAL
531312	Nonresidential Property Managers	FIREAL
531320	Offices of Real Estate Appraisers	FIREAL
531390	Other Activities Related to Real Estate	FIREAL
532111	Passenger Car Rental	FINOTH
532112	Passenger Car Leasing	FINOTH
532120	Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing	FINOTH
532210	Consumer Electronics and Appliances Rental	FINOTH
532220	Formal Wear and Costume Rental	FINOTH
532230	Video Tape and Disc Rental	FINOTH

532291	Home Health Equipment Rental	FINOTH
532292	Recreational Goods Rental	FINOTH
532299	All Other Consumer Goods Rental	FINOTH
532310	General Rental Centers	FINOTH
532411	Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing	FINOTH
532412	Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing	FINOTH
532420	Office Machinery and Equipment Rental and Leasing	FINOTH
532490	Other Commercial and Industrial Machinery and Equipment Rental and Leasing	FINOTH
533110	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	FINOTH
541110	Offices of Lawyers	PROLEG
541120	Offices of Notaries	PROLEG
541191	Title Abstract and Settlement Offices	PROLEG
541199	All Other Legal Services	PROLEG
541211	Offices of Certified Public Accountants	PROACC
541213	Tax Preparation Services	PROACC
541214	Payroll Services	PROACC
541219	Other Accounting Services	PROACC
541310	Architectural Services	PROARC
541320	Landscape Architectural Services	PROARC
541330	Engineering Services	PROARC
541340	Drafting Services	PROARC
541350	Building Inspection Services	PROARC
541360	Geophysical Surveying and Mapping Services	PROARC
541370	Surveying and Mapping (except Geophysical) Services	PROARC
541380	Testing Laboratories	PROARC
541410	Interior Design Services	PRODES
541420	Industrial Design Services	PRODES
541430	Graphic Design Services	PRODES

541490	Other Specialized Design Services	PRODES
541511	Custom Computer Programming Services	PROCOM
541512	Computer Systems Design Services	PROCOM
541513	Computer Facilities Management Services	PROCOM
541519	Other Computer Related Services	PROCOM
541611	Administrative Management and General Management Consulting Services	PROCNS
541612	Human Resources and Executive Search Consulting Services	PROCNS
541613	Marketing Consulting Services	PROCNS
541614	Process, Physical Distribution, and Logistics Consulting Services	PROCNS
541618	Other Management Consulting Services	PROCNS
541620	Environmental Consulting Services	PRORES
541690	Other Scientific and Technical Consulting Services	PRORES
541710	Research and Development in the Physical, Engineering, and Life Sciences	PRORES
541720	Research and Development in the Social Sciences and Humanities	PRORES
541810	Advertising Agencies	PROADV
541820	Public Relations Agencies	PROADV
541830	Media Buying Agencies	PROADV
541840	Media Representatives	PROADV
541850	Display Advertising	PROADV
541860	Direct Mail Advertising	PROADV
541870	Advertising Material Distribution Services	PROADV
541890	Other Services Related to Advertising	PROADV
541910	Marketing Research and Public Opinion Polling	PROOTH
541921	Photography Studios, Portrait	PROOTH
541922	Commercial Photography	PROOTH
541930	Translation and Interpretation Services	PROOTH
541940	Veterinary Services	PROOTH
541990	All Other Professional, Scientific, and Technical Services	PROOTH

551111	Offices of Bank Holding Companies	BUSSRV
551112	Offices of Other Holding Companies	BUSSRV
551114	Corporate, Subsidiary, and Regional Managing Offices	BUSSRV
561110	Office Administrative Services	BUSSRV
561210	Facilities Support Services	ADMBLD
561310	Employment Placement Agencies	ADMTMP
561320	Temporary Help Services	ADMTMP
561330	Professional Employer Organizations	ADMTMP
561410	Document Preparation Services	BUSSRV
561421	Telephone Answering Services	BUSSRV
561422	Telemarketing Bureaus	BUSSRV
561431	Private Mail Centers	BUSSRV
561439	Other Business Service Centers (including Copy Shops)	BUSSRV
561440	Collection Agencies	BUSSRV
561450	Credit Bureaus	BUSSRV
561491	Repossession Services	BUSSRV
561492	Court Reporting and Stenotype Services	BUSSRV
561499	All Other Business Support Services	BUSSRV
561510	Travel Agencies	BUSSRV
561520	Tour Operators	BUSSRV
561591	Convention and Visitors Bureaus	BUSSRV
561599	All Other Travel Arrangement and Reservation Services	BUSSRV
561611	Investigation Services	ADMSEC
561612	Security Guards and Patrol Services	ADMSEC
561613	Armored Car Services	ADMSEC
561621	Security Systems Services (except Locksmiths)	ADMSEC
561622	Locksmiths	ADMSEC
561710	Exterminating and Pest Control Services	ADMBLD

561720	Janitorial Services	ADMBLD
561730	Landscaping Services	ADMBLD
561740	Carpet and Upholstery Cleaning Services	ADMBLD
561790	Other Services to Buildings and Dwellings	ADMBLD
561910	Packaging and Labeling Services	ADMOTH
561920	Convention and Trade Show Organizers	ADMOTH
561990	All Other Support Services	ADMOTH
562111	Solid Waste Collection	ADMOTH
562112	Hazardous Waste Collection	ADMOTH
562119	Other Waste Collection	ADMOTH
562211	Hazardous Waste Treatment and Disposal	ADMOTH
562212	Solid Waste Landfill	ADMOTH
562213	Solid Waste Combustors and Incinerators	ADMOTH
562219	Other Nonhazardous Waste Treatment and Disposal	ADMOTH
562910	Remediation Services	ADMOTH
562920	Materials Recovery Facilities	ADMOTH
562991	Septic Tank and Related Services	ADMOTH
562998	All Other Miscellaneous Waste Management Services	ADMOTH
611110	Elementary and Secondary Schools	EDUC
611210	Junior Colleges	EDUC
611310	Colleges, Universities, and Professional Schools	EDUC
611410	Business and Secretarial Schools	EDUC
611420	Computer Training	EDUC
611430	Professional and Management Development Training	EDUC
611511	Cosmetology and Barber Schools	EDUC
611512	Flight Training	EDUC
611513	Apprenticeship Training	EDUC
611519	Other Technical and Trade Schools	EDUC

611610	Fine Arts Schools	EDUC
611620	Sports and Recreation Instruction	EDUC
611630	Language Schools	EDUC
611691	Exam Preparation and Tutoring	EDUC
611692	Automobile Driving Schools	EDUC
611699	All Other Miscellaneous Schools and Instruction	EDUC
611710	Educational Support Services	EDUC
621111	Offices of Physicians (except Mental Health Specialists)	MEDAMB
621112	Offices of Physicians, Mental Health Specialists	MEDAMB
621210	Offices of Dentists	MEDAMB
621310	Offices of Chiropractors	MEDAMB
621320	Offices of Optometrists	MEDAMB
621330	Offices of Mental Health Practitioners (except Physicians)	MEDAMB
621340	Offices of Physical, Occupational and Speech Therapists, and Audiologists	MEDAMB
621391	Offices of Podiatrists	MEDAMB
621399	Offices of All Other Miscellaneous Health Practitioners	MEDAMB
621410	Family Planning Centers	MEDAMB
621420	Outpatient Mental Health and Substance Abuse Centers	MEDAMB
621491	HMO Medical Centers	MEDAMB
621492	Kidney Dialysis Centers	MEDAMB
621493	Freestanding Ambulatory Surgical and Emergency Centers	MEDAMB
621498	All Other Outpatient Care Centers	MEDAMB
621511	Medical Laboratories	MEDAMB
621512	Diagnostic Imaging Centers	MEDAMB
621610	Home Health Care Services	MEDAMB
621910	Ambulance Services	MEDAMB
621991	Blood and Organ Banks	MEDAMB
621999	All Other Miscellaneous Ambulatory Health Care Services	MEDAMB

622110	General Medical and Surgical Hospitals	MEDHSP
622210	Psychiatric and Substance Abuse Hospitals	MEDHSP
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals	MEDHSP
623110	Nursing Care Facilities	MEDNRS
623210	Residential Mental Retardation Facilities	MEDNRS
623220	Residential Mental Health and Substance Abuse Facilities	MEDNRS
623311	Continuing Care Retirement Communities	MEDNRS
623312	Homes for the Elderly	MEDNRS
623990	Other Residential Care Facilities	MEDNRS
624110	Child and Youth Services	MEDSA
624120	Services for the Elderly and Persons with Disabilities	MEDSA
624190	Other Individual and Family Services	MEDSA
624210	Community Food Services	MEDSA
624221	Temporary Shelters	MEDSA
624229	Other Community Housing Services	MEDSA
624230	Emergency and Other Relief Services	MEDSA
624310	Vocational Rehabilitation Services	MEDSA
624410	Child Day Care Services	MEDSA
711110	Theater Companies and Dinner Theaters	RECENT
711120	Dance Companies	RECENT
711130	Musical Groups and Artists	RECENT
711190	Other Performing Arts Companies	RECENT
711211	Sports Teams and Clubs	RECENT
711212	Racetracks	RECENT
711219	Other Spectator Sports	RECENT
711310	Promoters of Performing Arts, Sports, and Similar Events with Facilities	RECENT
711320	Promoters of Performing Arts, Sports, and Similar Events without Facilities	RECENT
711410	Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	RECENT

711510	Independent Artists, Writers, and Performers	RECENT
712110	Museums	RECAMS
712120	Historical Sites	RECAMS
712130	Zoos and Botanical Gardens	RECAMS
712190	Nature Parks and Other Similar Institutions	RECAMS
713110	Amusement and Theme Parks	RECAMS
713120	Amusement Arcades	RECAMS
713210	Casinos (except Casino Hotels)	RECAMS
713290	Other Gambling Industries	RECAMS
713910	Golf Courses and Country Clubs	RECAMS
713920	Skiing Facilities	RECAMS
713930	Marinas	RECAMS
713940	Fitness and Recreational Sports Centers	RECAMS
713950	Bowling Centers	RECAMS
713990	All Other Amusement and Recreation Industries	RECAMS
721110	Hotels (except Casino Hotels) and Motels	ACCHOT
721120	Casino Hotels	ACCHOT
721191	Bed-and-Breakfast Inns	ACCHOT
721199	All Other Traveler Accommodation	ACCHOT
721211	RV (Recreational Vehicle) Parks and Campgrounds	ACCHOT
721214	Recreational and Vacation Camps (except Campgrounds)	ACCHOT
721310	Rooming and Boarding Houses	ACCHOT
722110	Full-Service Restaurants	ACCRST
722211	Limited-Service Restaurants	ACCFST
722212	Cafeterias	ACCFST
722213	Snack and Nonalcoholic Beverage Bars	ACCFST
722310	Food Service Contractors	ACCSPC
722320	Caterers	ACCSPC

722330	Mobile Food Services	ACCSPC
722410	Drinking Places (Alcoholic Beverages)	ACCBRS
811111	General Automotive Repair	PERSRV
811112	Automotive Exhaust System Repair	PERSRV
811113	Automotive Transmission Repair	PERSRV
811118	Other Automotive Mechanical and Electrical Repair and Maintenance	PERSRV
811121	Automotive Body, Paint, and Interior Repair and Maintenance	PERSRV
811122	Automotive Glass Replacement Shops	PERSRV
811191	Automotive Oil Change and Lubrication Shops	PERSRV
811192	Car Washes	PERSRV
811198	All Other Automotive Repair and Maintenance	PERSRV
811211	Consumer Electronics Repair and Maintenance	PERSRV
811212	Computer and Office Machine Repair and Maintenance	PERSRV
811213	Communication Equipment Repair and Maintenance	PERSRV
811219	Other Electronic and Precision Equipment Repair and Maintenance	PERSRV
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	PERSRV
811411	Home and Garden Equipment Repair and Maintenance	PERSRV
811412	Appliance Repair and Maintenance	PERSRV
811420	Reupholstery and Furniture Repair	PERSRV
811430	Footwear and Leather Goods Repair	PERSRV
811490	Other Personal and Household Goods Repair and Maintenance	PERSRV
812111	Barber Shops	PERSRV
812112	Beauty Salons	PERSRV
812113	Nail Salons	PERSRV
812191	Diet and Weight Reducing Centers	PERSRV
812199	Other Personal Care Services	PERSRV
812210	Funeral Homes and Funeral Services	PERSRV
812220	Cemeteries and Crematories	PERSRV

812310	Coin-Operated Laundries and Drycleaners	PERSRV
812320	Drycleaning and Laundry Services (except Coin-Operated)	PERSRV
812331	Linen Supply	PERSRV
812332	Industrial Launderers	PERSRV
812910	Pet Care (except Veterinary) Services	PERSRV
812921	Photofinishing Laboratories (except One-Hour)	PERSRV
812922	One-Hour Photofinishing	PERSRV
812930	Parking Lots and Garages	PERSRV
812990	All Other Personal Services	PERSRV
813110	Religious Organizations	PERSRV
813211	Grantmaking Foundations	PERSRV
813212	Voluntary Health Organizations	PERSRV
813219	Other Grantmaking and Giving Services	PERSRV
813311	Human Rights Organizations	PERSRV
813312	Environment, Conservation and Wildlife Organizations	PERSRV
813319	Other Social Advocacy Organizations	PERSRV
813410	Civic and Social Organizations	PERSRV
813910	Business Associations	PERSRV
813920	Professional Organizations	PERSRV
813930	Labor Unions and Similar Labor Organizations	PERSRV
813940	Political Organizations	PERSRV
813990	Other Similar Organizations (except Business, Professional, Labor, and Political Organizations)	PERSRV
814110	Private Households	PERSRV
921110	Executive Offices	NA
921120	Legislative Bodies	NA
921130	Public Finance Activities	NA
921140	Executive and Legislative Offices, Combined	NA
921150	American Indian and Alaska Native Tribal Governments	NA

921190	Other General Government Support	NA
922110	Courts	NA
922120	Police Protection	NA
922130	Legal Counsel and Prosecution	NA
922140	Correctional Institutions	NA
922150	Parole Offices and Probation Offices	NA
922160	Fire Protection	NA
922190	Other Justice, Public Order, and Safety Activities	NA
923110	Administration of Education Programs	NA
923120	Administration of Public Health Programs	NA
923130	Administration of Human Resource Programs (except Education, Public Health, and Veterans' Affairs Programs)	NA
923140	Administration of Veterans' Affairs	NA
924110	Administration of Air and Water Resource and Solid Waste Management Programs	NA
924120	Administration of Conservation Programs	NA
925110	Administration of Housing Programs	NA
925120	Administration of Urban Planning and Community and Rural Development	NA
926110	Administration of General Economic Programs	NA
926120	Regulation and Administration of Transportation Programs	NA
926130	Regulation and Administration of Communications, Electric, Gas, and Other Utilities	NA
926140	Regulation of Agricultural Marketing and Commodities	NA
926150	Regulation, Licensing, and Inspection of Miscellaneous Commercial Sectors	NA
927110	Space Research and Technology	NA
928110	National Security	NA
928120	International Affairs	NA

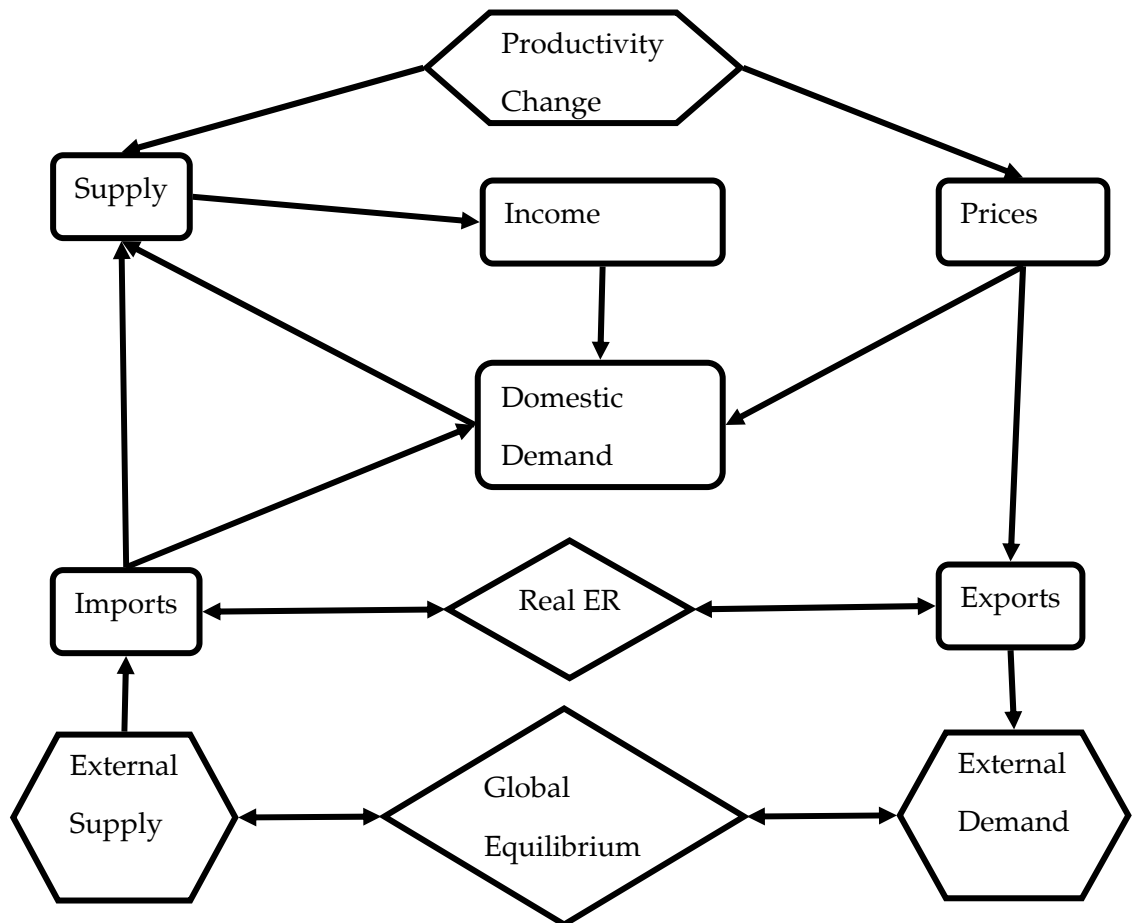
Appendix B

Model Calibration

Appendix B: Model Calibration

The model is calibrated to country and regional real GDP growth rates, obtained as consensus estimates from independent sources (Data Resources International, International Monetary Fund, Cambridge Econometrics). Using exogenous rates of implied Total Factor Productivity (TFP) growth, the model computes supply, demand, and trade patterns compatible with domestic and global equilibrium conditions. Equilibrium is achieved by adjustments in the relative prices of domestic resources and commodities, while international equilibrium is achieved by adjusting trade patterns and real exchange rates to satisfy fixed real balance of payments constraints. The general process is schematically represented in Figure B.1 below.

Figure B.1: General Equilibrium Calibration Mechanism



Appendix C

Notes on the Adjustment Process

Appendix C: Notes on the Adjustment Process

The calibration procedure highlights the two salient adjustment mechanisms in the model (as well as the real economies): domestic and international prices. General equilibrium price adjustments are generally well understood by professional economists but, in the multilateral context, the role of the aggregate price level can be a source of confusion. Generally, in a neoclassical model like this one, there are no nominal or financial variables and aggregate price changes (inflation or deflation have little meaning).

Because models like this do not capture the aggregate price level or other nominal quantities, there is no nominal exchange rate in the sense of traditional macroeconomics or finance. Since there is no money metric in the model, all prices are relative prices, and the exchange rate (the composite relative price of foreign goods) is no exception. If there were financial assets in the model, one could define a nominal exchange rate as the relative price of two international financial assets (money, bonds, etc.). Without them, the exchange rate is defined in terms of real international purchasing power, i.e., the relative price of tradable to nontradable goods. In a multi-sector setting, the real exchange rate is defined as the ratio of an index of the value of all tradables (on world markets) to an index of the value of all nontradables.

Since any tax (or other price elevating distortion) on an import is an implicit tax on all tradable goods, trade liberalization causes tradable goods prices to fall and the real exchange rate depreciates. Real exchange rate depreciation also makes exports more competitive, one of the principal motives for unilateral liberalization. The general implication of this is that trade will expand rapidly for a country removing significant import protection, and more rapidly for countries removing more protection. The pattern of trade expansion, and the domestic demand and supply shifts that accompany it, depend upon initial conditions and adjustments among trading partners.

It should also be noted that, even in a second-best world, removing price distortions also confers efficiency gains, increasing output potential and real incomes.